DOCUMENT RESUME

ED 051 640 95 EM 008 990

AUTHOR	Witherspoon, John P.; Kessler, William J.
TITLE	Instructional Television Facilities: A Planning Guide.
INSTITUTION	Office of Education (DHEW), Washington, D.C.
REPORT NO	OE-34043
PUB DATE	69
CONTRACT	OEC-1-7-071021-4429
NOTE	79p.
AVAILABLE FROM	Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. 20402 (FS 5.234:34043, $1.00)
EDRS PRICE	EDRS Price MF-$0.65 HC-$3.29
DESCRIPTORS	*Administrator Guides, Cable Television, Closed Circuit Television, Color Presentation, Consultants, Educational Administration, Estimated Costs, *Facility Requirements, Fixed Service Television, *Instructional Television, Media Selection, Open Circuit Television, Personnel Needs, Personnel Selection, Program Budgeting, *Program Planning, *Video Equipment, Video Tape Recordings

ABSTRACT

When planning an instructional television (ITV) system, it is suggested that educational objectives should outweigh technological considerations and that expert advice be secured before the planning process is far advanced. In line with the latter suggestion, the book offers a background of technical knowledge aimed at educational administrators who are involved in planning an ITV system. The possible uses for an ITV system and some overall planning considerations are surveyed. The test pattern concept for assessing the quality of a television picture is explained, and descriptive definitions offered of some basic ITV terms, such as broadcast quality, cable television, microwave, etc. Planning considerations for studios and studio equipment are outlined. Transmission options--open-circuit, cable, instructional television fixed service--are described, as are the links in the television reception chain--preamplifiers, modulated radio frequency systems, etc. Quadraplex videotape recorders are compared with slant-track recorders. Advice on preparing for color capability and on assembling an ITV staff is given. A basic planning pattern details the personnel who should be involved in the design stage and estimates the initial costs of an ITV system. (JY)

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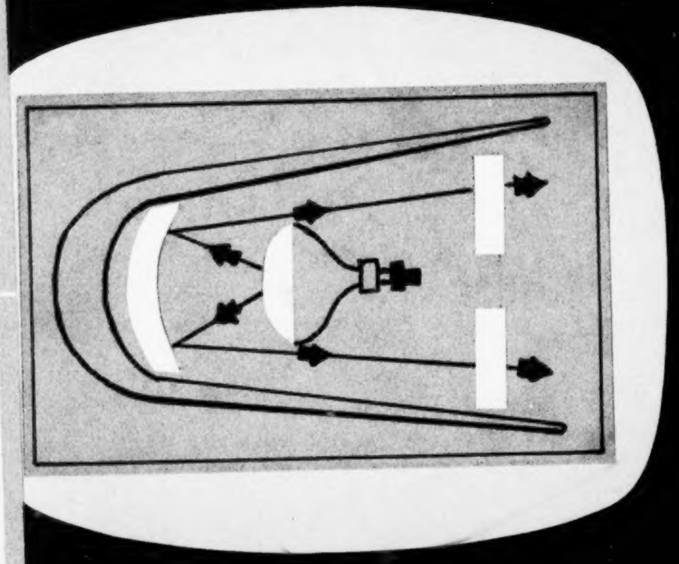

INSTRUCTIONAL TELEVISION FACILITIES

A Planning Guide

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Instructional Television Facilities: A Planning Guide

by
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and
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U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
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This publication was prepared pursuant to Contract No. OEC–1–7-071021-4429 with the Office of Education, U.S. Department of Health, Education, and Welfare. Contractors undertaking such projects under Government sponsorship are encouraged to express freely their professional judgment in the conduct of the project. Points of view or opinions stated do not, therefore, necessarily represent official Office of Education position or policy.

Superintendent of Documents Catalog No. FS 5.234:34043
UNITED STATES GOVERNMENT PRINTING OFFICE
WASHINGTON : 1969

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington, D.C. 20402 Price $1

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Chapter I

INTRODUCTION

ARISTOTLE was fond of the idea that the audience is the end and aim of the speech. The audience—the end and aim of this book—is the educational administrator, the man who says the final "yes" or "no" to a given instructional method or idea, and who commits his budget accordingly.

This individual is too often forced to spend really significant money and more importantly to make pervasive instructional decisions after a study of information that is technically, pedagogically, and administratively incomplete and unnecessarily subjective. One more book is not going to remedy that situation; but within the area of instructional television some simple technical cues can be provided that may, if necessary, be converted to danger signals. For example, practical information can be given an administrator on what to expect of consultants, how to understand television technology, and how to place television in perspective with other instructional systems.

The essential precepts of this book can be distilled into two simple sentences:

1. Think first about educational objectives and second about technology.
2. Get expert advice **before** the planning process is far advanced.

Undoubtedly, these matters are not quite as simple as they seem. Hardly anyone will admit that he bought a television package without considering its uses, but an honest few may concede that the specific objectives chosen and the equipment purchased turned out to have little in common. Others might put it differently: "We tried educational television and it didn't work."[1]

Educational television (ETV), as an instrument of instruction, has worked well in a variety of situations ranging from teacher-training classrooms, where it is often used as a self-observation device, to physician-training operating rooms, where it is used to give all students a better view than any of them could have in the familiar amphitheater. It has been used as a presentational tool for nearly any subject area taught in schools and colleges today, not excluding mathematics, typing, psychology, foreign languages, art, and physical education.

Television is properly called a medium, along with books and chalkboards. Like them, it offers a certain technical potential, a capacity for instructional utility, a set of advantages and limitations within which certain things are possible. Any medium may be used very well or very poorly.

Many administrators have recognized that television and other technology must play an important part in the reshaping of education now underway. But difficult problems arise, some related to philosophies of instruction; some tied to budget questions; and others concerned with the uncertainties of planning in an unfamiliar area with insufficient help. It is the last of these categories which is considered below.

CAPABILITIES OF EQUIPMENT

Television equipment today is available in a baffling variety of types, packages, and ranges of capability. Television cameras, like automobiles, have certain basic, common functions to perform. All automobiles provide transportation, and all television cameras convert light images into television signals. But the ideal car for freeway driving is hardly the optimum vehicle for churning over rutted back-country trails. Similarly, the television camera that is used to post flight information at metropolitan airports is not the camera used in the production of network drama.

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[1] This comment particularly infuriates people who work in educational communications, since it ignores poor planning and transfers blame to the medium. It is like swearing at a chair because you stubbed your toe.

To carry the comparison further, consider the simple snapshot cameras that children get for Christmas. These cameras may take excellent pictures, but the professionals on a local newspaper staff depend on somewhat more expensive models. It may be instructive to ask why.

When someone buys the more expensive camera—to make pictures on ordinary roll film or to make pictures electronically for television, he buys certain qualities, most important of which are operating dependability, technical characteristics of the picture, and the ability of the camera to operate under widely varying light conditions.

That is not to say that a press photographer's camera is **better** in all ways than a child's Christmas camera. Santa Claus recognizes such virtues as operating simplicity and low cost. Besides, little Suzie just doesn't **need** a camera that will show every minute detail of every relative who consents to be the young photographer's subject.

Thus, the question to examine now is not which equipment is good or not so good, but which equipment is needed to achieve stated educational goals.

NEEDS AND GOALS

You usually get what you pay for. But it is possible to get what you pay for and still not get what you need.

The decision to install an instructional television system may not be quite as profound as the decision to build a building, but the two have some things in common. Television hardware lasts over a period of years. It bears on the work of other parts of the instructional effort. The investment represents a decision regarding the overall hierarchy of priorities, and thus affects the administrator's relations with others.

Television is used for a great range of tasks, including (but by no means limited to)—

- The presentation of prepared instructional materials to students in classrooms
- The presentation of instructional or broadly educational materials to people in their homes
- The presentation of experiences which are difficult to present in person, such as actual surgical demonstrations to medical students or teaching techniques to student teacher groups
- An autoinstructional device to allow observation of one's own performance, as in classroom teaching situations, sports, or many kinds of physical skills
- Simple security surveillances (as in apartment houses), posting of up-to-date information (as in airports), and observation of laboratory processes dangerous to human observers
- Magnified images to show microscope slides to whole classes, and detailed drawings or formulas to large groups

Within these broad categories there are great variations. For instance, relate to a television station the first of the aforementioned categories, presentation of prepared instructional materials to students in classrooms. Certain requirements are mandatory within the television station: a large studio probably equipped with three high-quality cameras mounted on heavy, steerable pedestals; a flexible lighting system; the capacity to handle at least a half dozen microphones; related picture and sound sources including professional quality film projectors, audio and video tape recorders, slide projection equipment, and audio turntables; an intercommunication system connecting director, control room crew and studio crew; sophisticated switching equipment for picture and sound; and the latest equipment for recording the finished product. This studio probably has the backup services of a fully equipped scene shop, an electronic maintenance facility, photographic services, graphic production services, and professional management.

On the other hand, an individual school may have an installation that receives the ETV station's signals off the air, plays back materials from a small video tape recorder or film projector, and displays these materials on classroom television sets of good quality. For its specialized needs, the school may also have one or two cameras of adequate if modest quality, a microphone or two, and a few lighting instruments. For their respective purposes, the television station and the school may both have installations they properly consider appropriate.

The lesson of the preceding paragraphs, obvious as it seems, is often overlooked: both installations are appropriate; both answer the same broad statement of need. But they are fundamentally dissimilar, and the product of one cannot be equated fairly with the product of the other.

Furthermore, the school's equipment and that of the ETV station probably differ not only in quantity, but also in kind. The school needs equipment that is rugged, easy to operate and maintain, takes up little space, and is relatively inexpensive. The television station needs equipment that is as flexible as possible, generates picture and sound of highest possible quality, and can be used with varying lighting conditions and in situations requiring unusual technical effects. Roughly speaking, the trade-offs are costs (both capital and operating) versus quality and flexibility.

When one examines other uses of television, other factors must be considered. Suppose the system is to be used for the simple observation of people or processes. The cameras most suited for that work are among the least expensive, and purchase of costly studio equipment usually would be a technical as well as a financial error.

To return to the two cardinal principles—start with carefully stated objectives and get qualified consultant help early—the following should be considered in planning:

1. Make a large enough investment in space so that growth will not cause a major upheaval. Buy equipment for broader uses than the first planned applications. The inadequacies of many installations can be traced to the fact that people are "making do" and "patching together" because their initial decisions were too restricted.

2. Find out what others are using before buying equipment. This is not merely a matter of sharing wisdom but of capability to exchange certain materials with other centers. The latter is possible only with compatible equipment that "speaks" the same electronic language.

3. Purchase reliable and stable equipment, remembering that the cheapest equipment may not be the best buy. Reliability and operating stability are the two prime requirements of electronic equipment, and both cost money. Unsatisfactory equipment performance is one of the reasons why some report: "We tried educational television and it didn't work."

4. Look ahead as far as possible. The decision to use television is presumably in response to a present need, but the equipment will still be there when the original context has changed. Educational communication is currently the subject of much long-range study and serious technological development. To ignore it as abstruse or futuristic is unwise and ultimately uneconomical.

In summary, television can be used in a great many ways. Equipment needs vary with the tasks to be performed. Careful survey of initial needs and painstaking, informed determination of initial goals are essential to a really successful operation. At the same time, systems grow and needs change, and in most situations it is unwise to work from a plan that does not easily permit evolution.

SOURCES OF ITV MATERIALS

In planning for instructional television, many administrators fall into the habit of thinking about **reception** of broadcast materials in the classroom and/or **production** of materials locally. In fact, ITV materials take many routes to the classroom consumer, and systems should be designed with various options in mind. Materials may be—

- Produced locally for local consumption.
- Distributed to many users by national or regional centers. The most widely known ones are the National Instructional Television in Bloomington, Ind., and the Great Plains National Instructional Television in Lincoln, Nebr.

- Exchanged between centers. These agreements are often informal, based on the simple realization that no individual alone has a corner on good teaching.

Once an interest in television has been established, many institutions plan immediately for local production on the premise that nothing presently available quite suits the local situation. As a practical matter, a process like the following often takes place:

1. It is decided that local needs are unique in various ways, and as a result the local institution acquires a production capability.

2. It is apparent that this area of uniqueness is not nearly so great as earlier estimates indicated.

3. It is discovered that nationally distributed materials are available in better quantity and quality than earlier estimates indicated. Furthermore, television uses are expanding to the extent that local production could not do the job alone.

4. Certain local programs are "discovered" by nearby systems, and are traded for some of the better programs of these neighbors. With the incentive of broader distribution, and with local pride at stake, greater effort is invested in such programs and the quality goes up.

5. The best of these efforts are "discovered" by the National Instructional Television or the Great Plains ITV Library. Adjustments are made to upgrade production or to make the programs valid nationally, and they go into nationwide distribution.

This development pattern has some specific implications for system design. If exchanges are to take place, equipment must be compatible. This is a matter which should be studied seriously and about which expert advice is necessary. These questions should be raised: Is local production really a requirement? Are national sources sufficiently developed that they alone could serve local needs?

APPROPRIATE SYSTEM DESIGN

From the foregoing, it can be seen that television planning should survive some tough tests before it is translated into equipment and payroll. Among the major questions to be asked by the educational administrator are these:

1. What are the educational needs and goals? What are realistic priorities?

2. Precisely how should television fit into this context? Exactly what should it do?

3. What is ahead in the whole relationship between education and technology? How will the television system likely be used in 5 years? In 10 years?

4. What television materials are now available to meet the educational demands? What other television centers exist, and how can their facilities be used?

5. In planning for space, hardware, and personnel, precisely how are the plans responsive to the above questions?

Chapter II

THE RIGHT MEDIUM FOR THE JOB

THE RANGE of available instructional media becomes more and more impressive as technology develops. Among these developments are TV, radio, programed instruction, films, slides and other still pictures, computer-aided learning systems, audio devices such as language laboratories, dial-access information systems, blackboard-by-wire, and (just on the horizon) applications of slow-scan television and facsimile.

In considering the right medium for the job, one is forced to study the characteristics of the techniques available. For example, one might say that television provides:

- Sound of reasonably high quality
- Pictures of moderately good resolution
- The illusion of motion
- Color as an option at considerable cost
- Instant transmission if needed, or use of videotape
- Relative ease of classroom use on familiar receiving equipment

Taken alone, however, television does not provide student feedback, and the student's pace is determined primarily by the present distribution pattern of the material.

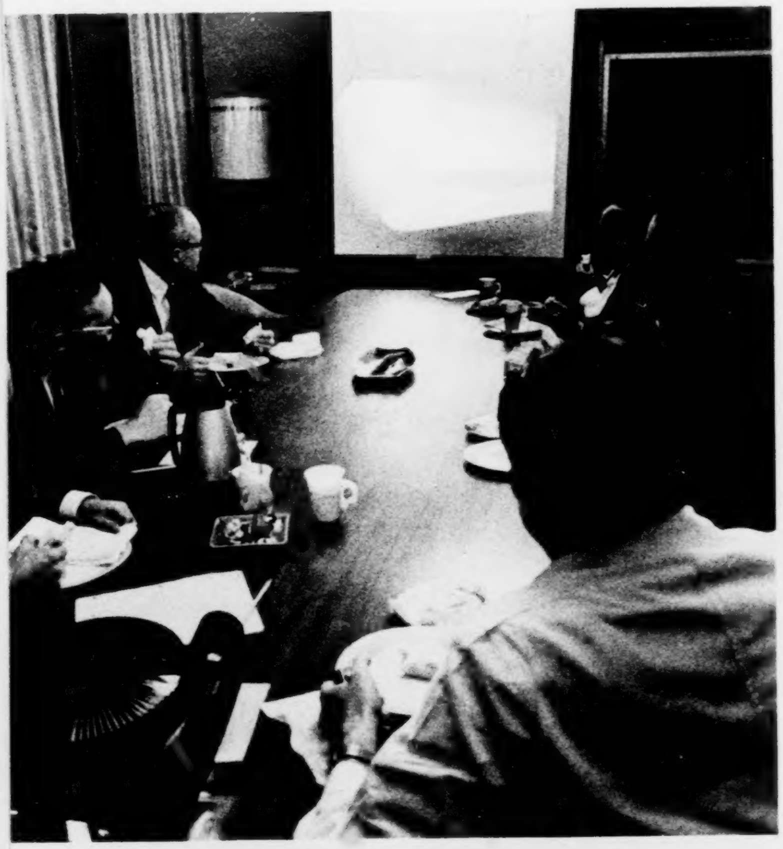
Compare this list of TV characteristics with one that might be developed for other media. Computer-aided learning systems have instant feedback, a more individualized approach to learning, and a capability of displaying material of various kinds; but the per student cost is much higher and the system is not presently useful for displaying information to large groups. Radio has many of the distributional advantages of television and, if one may sacrifice video in given cases, offers impressive advantages in terms of economy and efficiency. Careful consideration should be given to the advantages of adding color to the various media, although some research has indicated that illusions of motion and/or color frequently fail to make significant contributions to some learning tasks—in fact, may in some instances actually detract from learning.

As technological advancements are used more and more in education, it becomes possible through sheer volume to use them better. Likewise, as more media are added to the arsenal, it becomes possible to study their relationships with each other. If a large school system has at its disposal a well-equipped audiovisual center, a television system, a radio station, and perhaps a computer-aided learning project, its administrators may ask which techniques can be used in combination. Here are some of the combinations now in use:

- A radio station is used to provide a second sound track in another language for a television program.
- An FM stereo station carries an orchestra's music while a television station broadcasts the picture.
- A radio station carries lecture material in conjunction with locally projected color slides.
- A radio or television station uses telephone lines to provide feedback from students or classes.
- Various production sources prepare materials for display in dial-access or computer-mediated learning systems.
- Telephone techniques are used for distant speakers, questions from audiences, and transmission of "notes" via electrowriter or blackboard-by-wire systems.

Many other variations could be listed, but the above present the essential lesson: (1) Decide on objectives, (2) survey the facilities available, and (3) choose a strategy that is likely to achieve the objectives while making the most efficient and

Fig. 1. Radio and color slides are used effectively in postgraduate medical training program.



Hospital group viewing color slides and listening during lunch hour

WAMC studio, showing moderator and the "electronic hand raiser"

A hospital group coordinator using "black box" equipment to ask questions economical use of existing resources. A secondary lesson: Try to avoid over-commitment to **one** medium or **one** technique. To illustrate, in the following case study the right medium was not television, but an exceptionally imaginative radio system. (See figure 1.)

For relating educational objectives, efficient and economical use of facilities available, and long-range good results, the educational FM station WAMC, operated by the Department of Postgraduate Medicine, the Albany Medical College of Union University is a study in ingenuity. This station is headquarters for an operation that takes **illustrated** lectures in postgraduate medicine to physicians located in about 70 hospitals in eight States, and then allows the physicians to ask questions of the lecturer while the other "seminar" participants listen. Participating faculty members, heard live, are from medical schools as widely separated as the University of Vermont, Yale, Johns Hopkins, the University of North Carolina, the University of Rochester, and the University of Wisconsin. Approximately 30 medical schools participate in the project which has been underway since 1958.

Some of the following resources are used:

- Station WAMC Albany and three other educational FM stations, located in New York City, Boston, and Canton, N.Y.
- Class D telephone lines
- Cable TV systems
- Radio relays similar to those used by taxicab companies
- Multiple copies of high-quality color slides projected locally in the hospitals
- The secondary-channel multiplex capabilities of FM stations
- Audio tape recording

Imagine that one of the two-way radio conferences is about to begin. The subject is "Serum Enzymes in Diagnosis," and the two visiting faculty members from the University of Toronto, Canada, are in an office at their university. This session is addressed to physicians in 15 hospitals in four States. In each hospital, the doctors are gathered around a table in a room that also contains an FM radio, a slide projector and screen, and a supply of box lunches. (It had been found that lunchtime was the ideal period for these people to meet.) Each room also had a small "black box" transmitting device and a microphone. By pushing a button on the box and speaking into the microphone, this seminar group is in touch with all the other groups and with the guest lecturers.

The broadcast begins at noon sharp. In Albany a moderator in the WAMC studio invites the participating hospitals to check in. They do so: Pittsfield, Mass.; Lewiston, Maine; Cohoes, N.Y.; Hartford, Conn.; Biddleford, Maine; and others. As each hospital chairman pushes the button on his transmitter, a labelled light goes on in the WAMC studio's "electronic hand-raiser"; and as the local hospital chairman speaks, his voice is heard by the other participants throughout the Northeast.

As the lecture begins, the voices of the two faculty members come initially not from Toronto, but by high-quality tape recording played from Albany. This is both a convenience and an economy measure. A low-cost phone line from their office to the studio is of sufficient quality for short answers to questions, but it would be annoying for a full half-hour lecture. Also, the use of recording eliminates the need for the visiting experts to repeat their lectures in subsequent sessions for other hospitals.

From time to time, the taped voice of the professor directs attention to a slide, one of perhaps 25 that had been duplicated and shipped in advance to the hospital.

As the lecture progresses, questions or comments occur to participants at the various hospitals. To signify that its members wish to be recognized, a group presses the button on its transmitter, and in the WAMC studio a light goes on just below a small label that says "Maine Med. Ctr., Portland" or "Mt. Sinai, Hartford, Conn." At the conclusion of the lecture, the moderator calls on the hospital groups that have signalled. Through an inexpensive relay system, the question or comment is stated. The visiting faculty members—now speaking from their Toronto headquarters–respond. This multistate, international dialog continues for half an hour. At precisely 1:00 p.m., the program ends.

A project as far-flung and impressively useful as this would be presumed to carry an equally weighty price tag. But the whole operation is housed in a comfortable post-Victorian house in Albany, and there is space for other activities. Since 1958, total investment in studios, control room, transmitter (located atop Mount Graylock), studio-transmitter microwave link, recording and duplicating facilities, test equipment, plus all the hospital-based equipment, has amounted to only $175,000. The annual operating cost is $120,000. There are seven staff members in administration, engineering, programing, and production, plus four clerks and three part-time students who operate the control board. Seven of the college's Department of Postgraduate Medical Education are regularly involved.

When the station finishes its medical work, it provides an impressive schedule of noncommercial radio programing for listeners at home. The cost of that function is included in the aforementioned dollar figures.

The major point, however, is not economy, but the fact that this system is a well-developed, thoroughly appropriate solution to a specific problem. It is a valid means to the realization of carefully defined objectives.

MULTIMEDIA SYSTEM DEVELOPMENT

Suppose you have decided to invest in an instructional television system. Before the initial equipment reaches the end of its useful life, you will probably have to decide how your ITV facility should evolve into, or at least relate to, a larger multipurpose educational communications activity. That seems a safe prediction because of the following succession of developments:

1. During the late 1950's there was serious planning among the Big Ten universities about ways in which a Big Ten radio network might be developed so as to offer a whole range of information and communication services to their institutions. A preliminary study of the matter was conducted by Carl Menzer, the veteran broadcaster heading Station WSUI at the University of Iowa.

2. In 1962, the National Association of Educational Broadcasters began its Educational Communications System project, based on the hypothesis that a truly multipurpose communications system could be of academic, administrative, and economic importance to American colleges and universities. The idea was warmly received by the institutions. Pilot networks were designed, involving the members of the Committee on Institutional Cooperation (The Big Ten and the University of Chicago), the Oregon State System of Higher Education, and an East Coast model emphasizing "nonacademic" institutions that have considerable contact with universities, such as major research libraries and laboratories.

3. About the same time, there emerged independently the Interuniversity Communications Council (EDUCOM), which developed from the field of medicine but which moved to include many disciplines and many communication modes.

4. Major computer-oriented projects such as MEDLARS at the National Library of Medicine demonstrated the large-scale use of current information in electronic data form.

5. Several technological advancements immediately lent even greater currency to these developments. Chief among these was the great surge in the use of computers and the increasing utility of communications satellites. There were studies involving the use of satellites to serve regions, or even as the core of communication systems in major States such as California. There was considerable discussion of the use of satellites for the exchange of computer data, utilizing broadband channels and very high transmission rates. Satellite-to-home television systems were shown to be practical if not imminent.

6. In his remarks on signing the Public Broadcasting Act of 1967, in November of that year, President Lyndon Baines Johnson stressed the worldwide Network for Knowledge which would incorporate broadcast communications media, computer systems, and satellite transmission systems to benefit worldwide education. The Communications Satellite Corporation (Comsat) immediately expressed its readiness to begin domestic experimentation in the field. The Networks for Knowledge Act was introduced in Congress in 1968.

7. Patterns of business organization followed, and in some cases led, the rapid technological development. For example, the General Learning Corporation was formed in 1967 by General Electric and Time, Inc., which 10 years earlier would have seemed an unlikely combination. A complex of mergers and working relationships between hardware and software interests developed, causing major complications in the operation of the United States copyright law.

One can predict with some confidence, then, that today's instructional television system will face a challenging and perplexing evolution during the next decade. Since it is not possible to chart the evolution with precision, it will be worthwhile to consider a few guidelines contributed by others who have already been "through the mill."

- Build a reasonable amount of excess capacity into your system.
- Use equipment that is as broadly compatible as possible.
- Where possible, build in modular units so that important changes and additions can be made with a minimum of extra cost.
- Before starting, get the best consulting help you can afford, both in engineering and in system design at the level of operating policy.
- Build a financial capacity for change into future budget projections.
- Assure that principal staff members have every opportunity to stay abreast of technical developments, experimental projects, and operations of major centers elsewhere.

Chapter III

A PRIMER OF TELEVISION ENGINEERING

TOO MANY PEOPLE turn away from engineering fundamentals that are not really difficult. True, the educational administrator is properly more concerned about **tax** rates than **scanning** rates. What follows in this chapter is a discussion of some of the basic fundamentals.

THE TEST PATTERN CONCEPT

When an engineer evaluates a television system, one of his most valuable tools is the EIA[1] test pattern. This is nothing more than a "standard picture," and the engineer is so familiar with it that he remembers all its minute details. When he sees this test pattern rendered by various parts of a television system, he can diagnose troubles and assess various picture impairments accurately and objectively.

Valuable as it is, the EIA test pattern tells more than the administrator needs to know. For our purposes, the number of TV picture characteristics can be reduced to four. The engineer, in his accurate but opaque way, refers to these as:

- Scanning linearity
- Gamma response
- Detail contrast
- Video signal-to-noise ratio

Interpreted, these become:

- Geometric accuracy of the TV image
- Gray-scale reproduction
- Resolution
- Picture-to-snow ratio

GEOMETRIC ACCURACY OF THE TV IMAGE.—As you look at the picture in figure 5, are the circles round? Are the squares square? Geometric distortion, or the skewing or stretching of the reproduced picture, occurs when the picture tube "paints," or scans, the picture at uneven off-standard speeds. Scanning part of the picture too fast stretches the image; scanning too slowly squeezes it. This problem can occur in the originating camera or in the TV set. Unlike other common impairments, this one is caused only by the camera or receiver; none of the intermediate hardware has anything to do with geometric accuracy.

GRAY-SCALE REPRODUCTION.—In a good television system there should be at least 10 evenly spaced standard shades of gray, ranging from reference white to reference black. A system of good quality, well maintained and in good adjustment, will see and display them all. If the system is of lesser quality, poorly maintained, or out of adjustment, the gray scale response will be unbalanced. The picture may be washed-out white or muddy.

RESOLUTION.—A system's resolution is its ability to show fine detail in the reproduced image. The problem of reproducing small details in a TV picture is similar to that faced by newspaper or magazine publishers. The major difference is that the publishing industry uses a dot structure to reproduce photographic half-tones, whereas television uses a system of horizontal lines. These differences are illustrated in figure 2. Obviously, resolution is determined in print by the number of dots per square inch and in television by the number of lines per inch.

There is, however, an additional complication. A look at the dot structure of a printed picture

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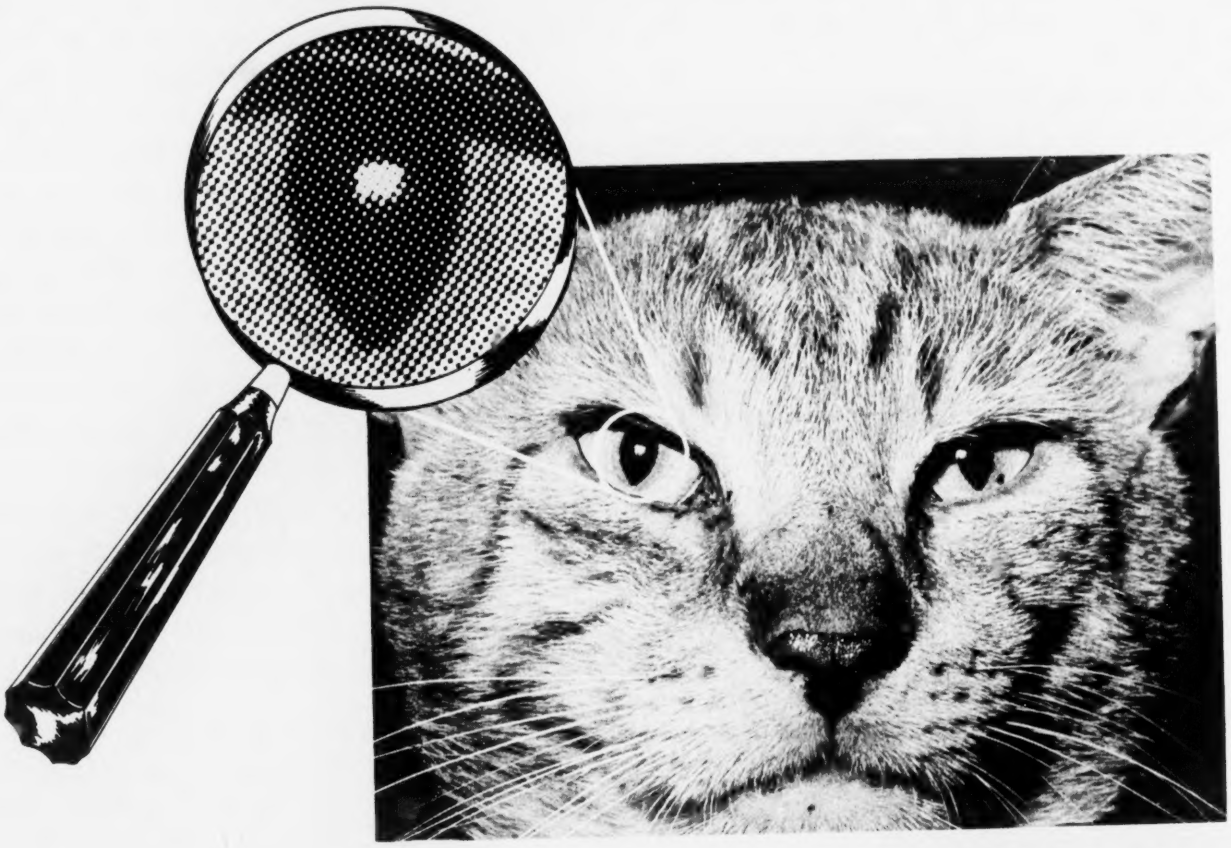
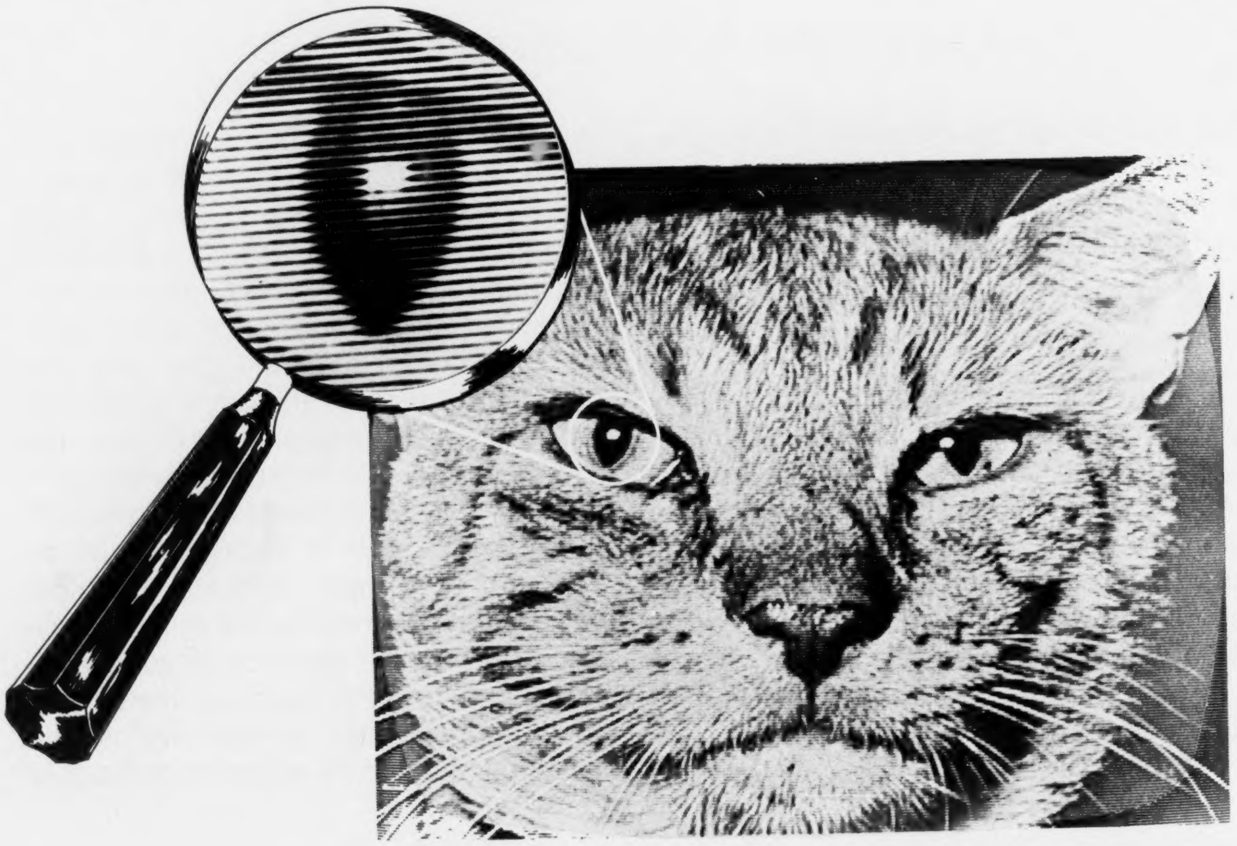
[1] Electronics Industries Association, which sets various technical standards.

Fig. 2. How is the cat's eye reproduced?



a. Printing uses a system of dots.

b. Television uses a system of horizontal lines.



will easily demonstrate that there is equal resolution horizontally and vertically. In television, however, the resolution in the horizontal direction usually exceeds the resolution in the vertical direction.

The television picture is composed of a standard number of horizontal lines; in the United States, the standard number is 525. Since there are always 525 lines between the top and bottom of the picture, vertical resolution will not vary much. Some of these lines are displaced by synchronizing pulses, and some are effectively canceled by small scanning errors; but vertical resolution in any good system will turn out to be about 370 lines.

Horizontal resolution is another matter. It is not primarily related to scanning standards but to a transmission characteristic called video bandwidth. To increase horizontal resolution, one increases video bandwidth.[2] Different television systems use video bandwidths ranging from as low as two megahertz to perhaps 12 mHz.[3] A common video bandwidth is 4.2 mHz, since that is the theoretical point at which horizontal resolution equals vertical resolution.

It should be noted also that several other matters affect resolution, but most of them may be controlled by good maintenance practices.

PICTURE-TO-SNOW RATIO.—Any viewer knows what television snow looks like, and knows that it is to be avoided. It is the video equivalent of hissing or static on a radio or telephone—random electrical disturbances that are omnipresent in varying amounts in any communication system.

The object of the television system is to present lots of picture with little snow, since snow reduces clarity, serves to divide the focus of attention, and generally detracts from the usefulness of the picture. The object, then, is to design systems with a high picture-to-snow ratio or, to be a little more precise, to design systems with a high video signal-to-noise ratio.

Although the engineer has no objective means to measure the picture and snow levels as they appear on the television screen, he can measure the video signal-to-noise ratio at the input to the receiver; and he can do it in terms that are accurate, convenient, and universally understood.[4]

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[2] Video bandwidth costs money. The cheaper videotape recorders, for example, use relatively narrow bandwidths and have relatively poor horizontal resolution.

[3] Hertz—one cycle per second; megahertz—one million cycles per second. The symbol of the two combined is mHz. This term is discussed in more detail later in this chapter.

[4] "Universally understood" is an engineering term meaning "likely to be intelligible to other engineers."

A NEW LOOK AT TEST PATTERNS

For this book, the authors have devised a special kind of test pattern, or standard picture, to illustrate the four basic characteristics of television systems,[5] as shown in figure 3.

- **GEOMETRIC DISTORTIONS** can be seen in the shapes and relative sizes of the circles and squares.
- **GRAY-SCALE REPRODUCTION** is shown by the varying gray shades inside the circles. Numbers are imbedded in the gray circles, and the shade of the number is exactly one shade darker or lighter than its background. Reference white (standard shade of gray number one) is shown in the upper left circle. Imbedded in it is the number **2,** which is printed in standard shade number two. Reference black (standard shade number ten) is shown by the circle in the lower right-hand corner. Imbedded in reference black is the number **9** printed in shade number nine. The background gray of the large center circle is standard shade number five, the approximate center of the gray-scale spectrum. The idea of "imbedding" numbers of one gray scale in a background of an adjacent gray scale provides a simple and dramatic demonstration of good gray-scale rendition or the lack of good gray-scale rendition. For example, merely the ability to detect the number against the background in the TV reproduced image is

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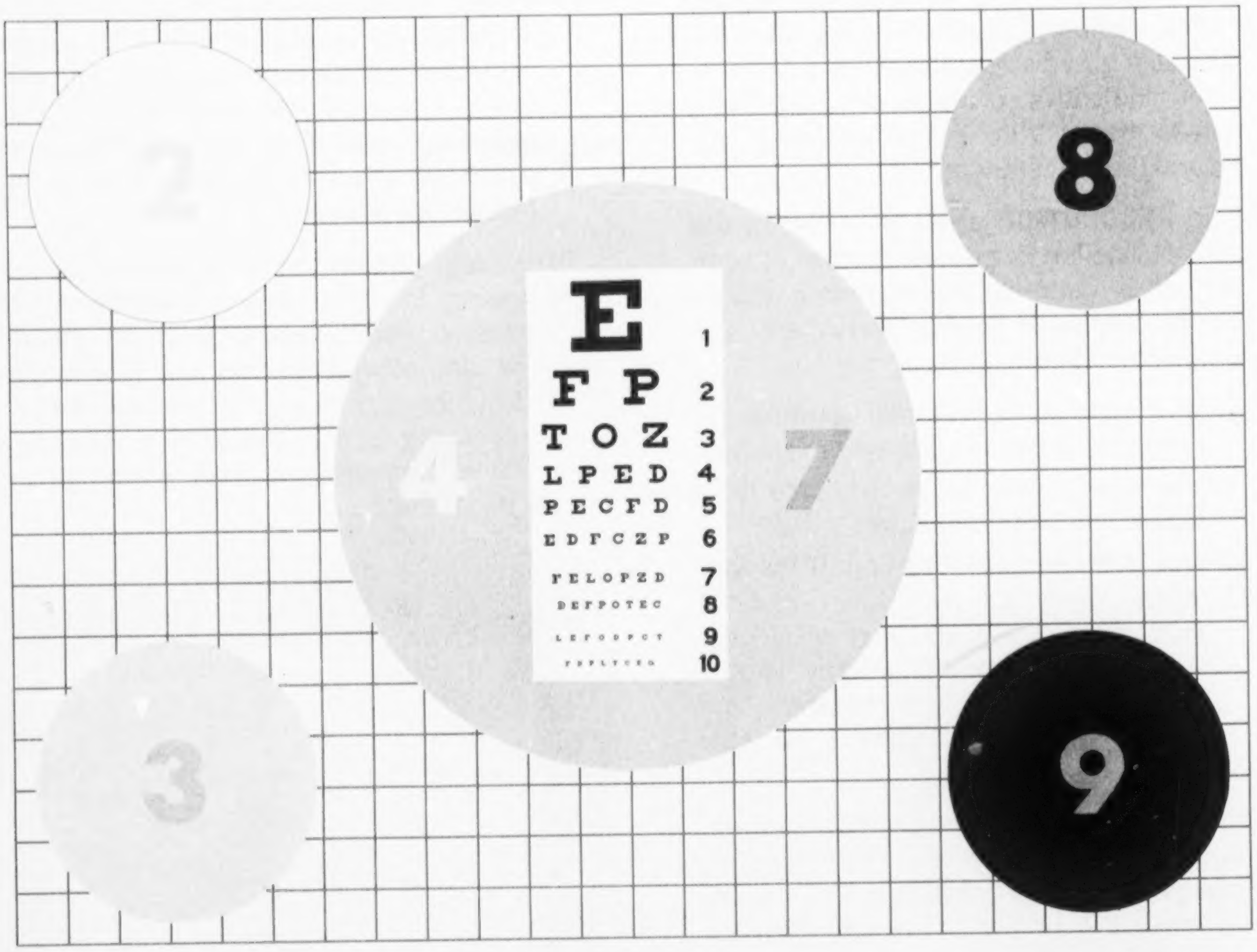
[5] For the purpose of this book, the ingenious EIA test pattern is somewhat too complicated.

Fig. 3. Direct reproduction of simplified test pattern or standard picture that may be used to determine the quality of television reception.


2
8
E 1
F P 2
T O Z 3
L P E D 4
P E C F D 5
E D F C Z P 6
F E L O P Z D 7
D E F P O T E C 8
9
10
4
7
3
9

indicative of good gray-scale rendition in that particular portion of the tonal range, since this demonstrates that the system is capable of resolving or displaying adjacent shades of gray. Conversely, if the number imbedded in the adjacent shade of gray background cannot be seen, it is indicative of poor or inadequate gray-scale rendition in that particular portion of the tonal range.

- The **RESOLUTION** chart is based on the simple Snellen Eye Chart. The use of such a chart to illustrate the resolution quality of TV hardware seems particularly appropriate because it:

  —is a standardized image familiar to anyone who has had his eyes examined.

  —is designed, after all, to check the resolution capability of the eye.

  —provides a direct indication of the system's ability to reproduce readable print of various sizes. Lines of horizontal and vertical resolution may be subject to individual interpretation, but ITV systems must reproduce readable print.

  There is, of course, a correlation between reproducible type size and the amount of needed horizontal resolution in TV lines, as measured by EIA standards. Figure 4 shows this relationship.

- **PICTURE-TO-SNOW RATIO** is demonstrated by certain of the illustrations in figure 5. Reproductions of the simplified test pattern seen on a television screen show various impairments caused by the television system. Figures 5–A and B show the white and black compression, C and D poor vertical and horizontal linearity, E poor resolution, and F through I demonstrates picture-to-snow ratio. As indicated earlier, engineers measure this technically as video signal-to-noise ratio at the receiver input. Their unit of measure is the decibel (db). In the illustrations the television systems were adjusted to provide signal-to-noise ratios of 40 db, 35 db, 25 db, and 15 db. A signal-to-noise ratio of 25 db is generally regarded by engineers as the poorest quality that most at-home viewers would tolerate before switching to another channel. In a later section it will be demonstrated that, even if you are willing to settle for a signal-to-noise ratio of 25 db at the television set, you need a lot better than that at the front of the system.

These four picture characteristics as described here are not the only ones that matter. Systems also develop black streaking, white streaking, ghosting, and other problems. For now, however, these troubles can be left to the engineers. Before proceeding further and to keep communication flowing smoothly, a few essential terms should be defined.

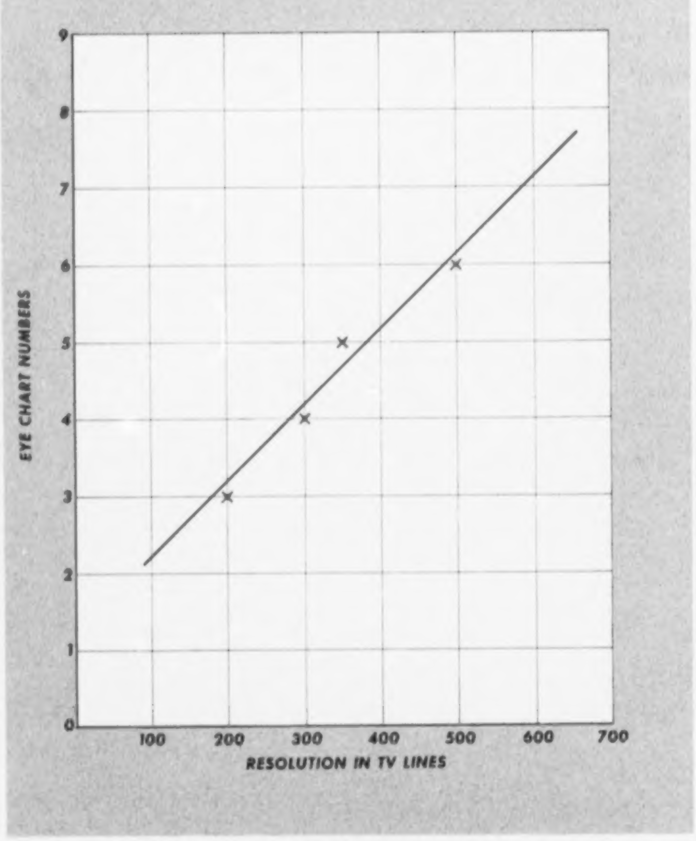
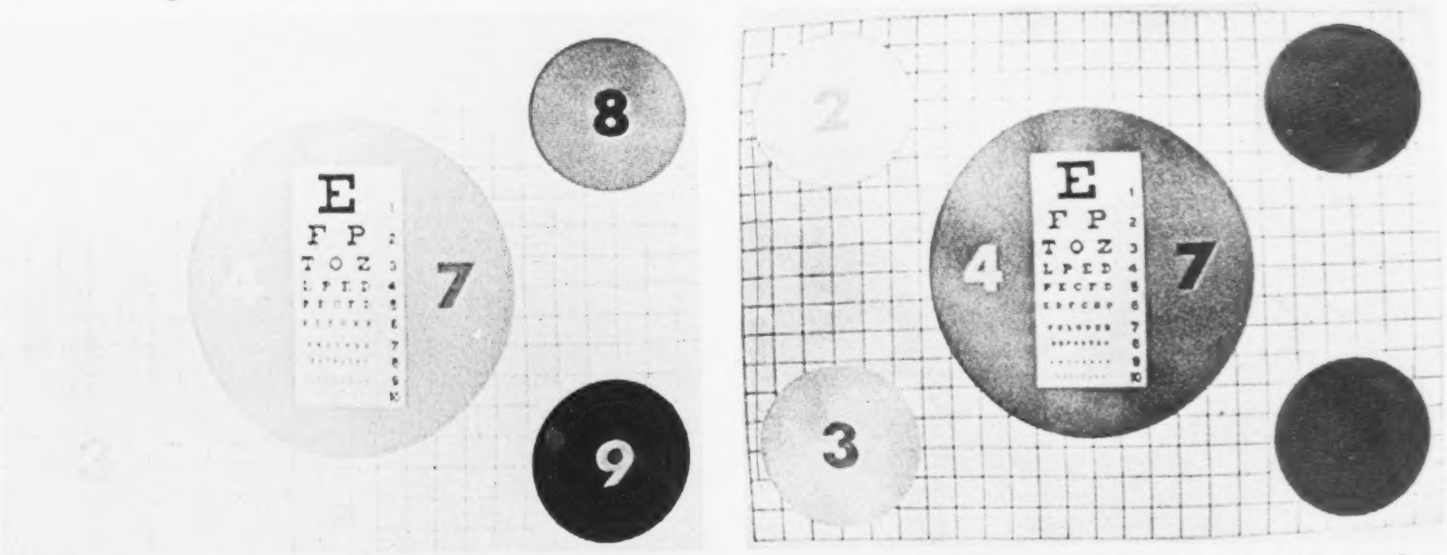


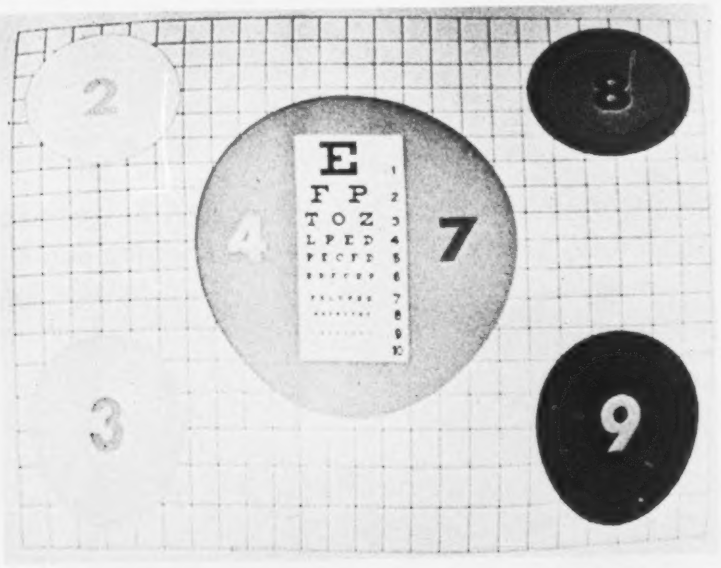
Fig. 4. The relationship between reproducible type, as shown on the Snellen eye chart, and amount of needed resolution in TV lines.

Fig. 5. Reproductions of the simplified test pattern as seen on a television screen.

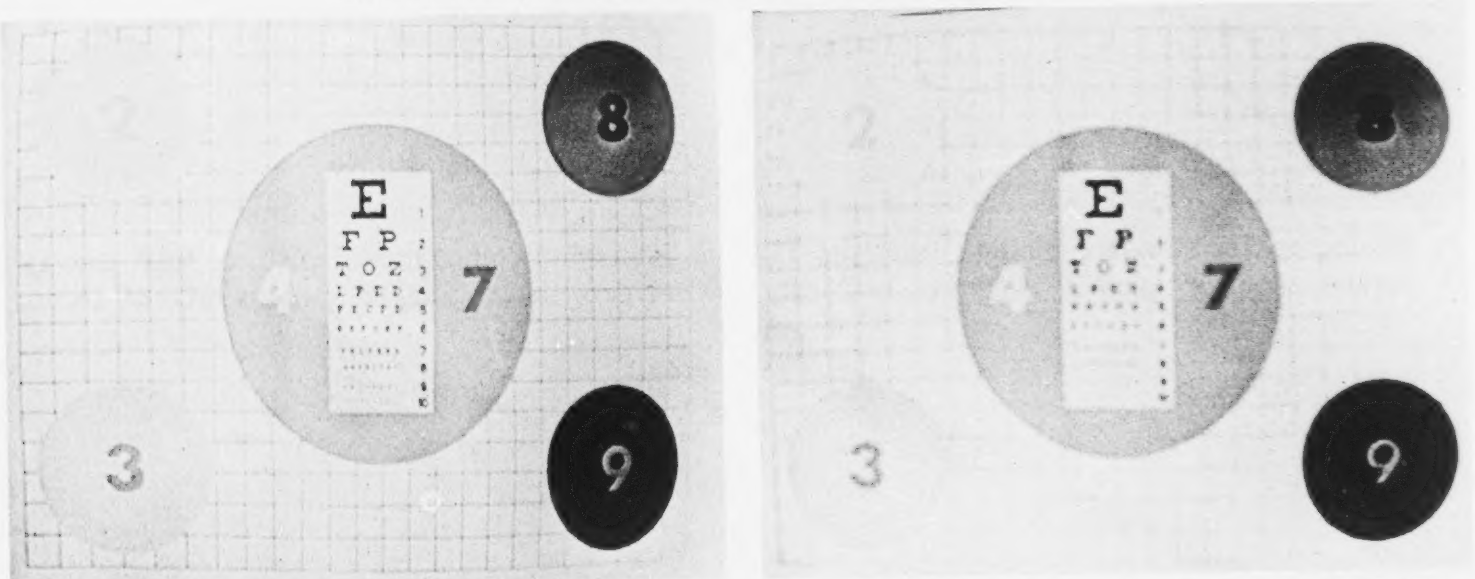

2
8
E
F P
T O Z
4
7
3
9

a. Standard picture, showing white compression

b. Standard picture, showing black compression


2
8
E
F P
T O Z
4
7
3
9

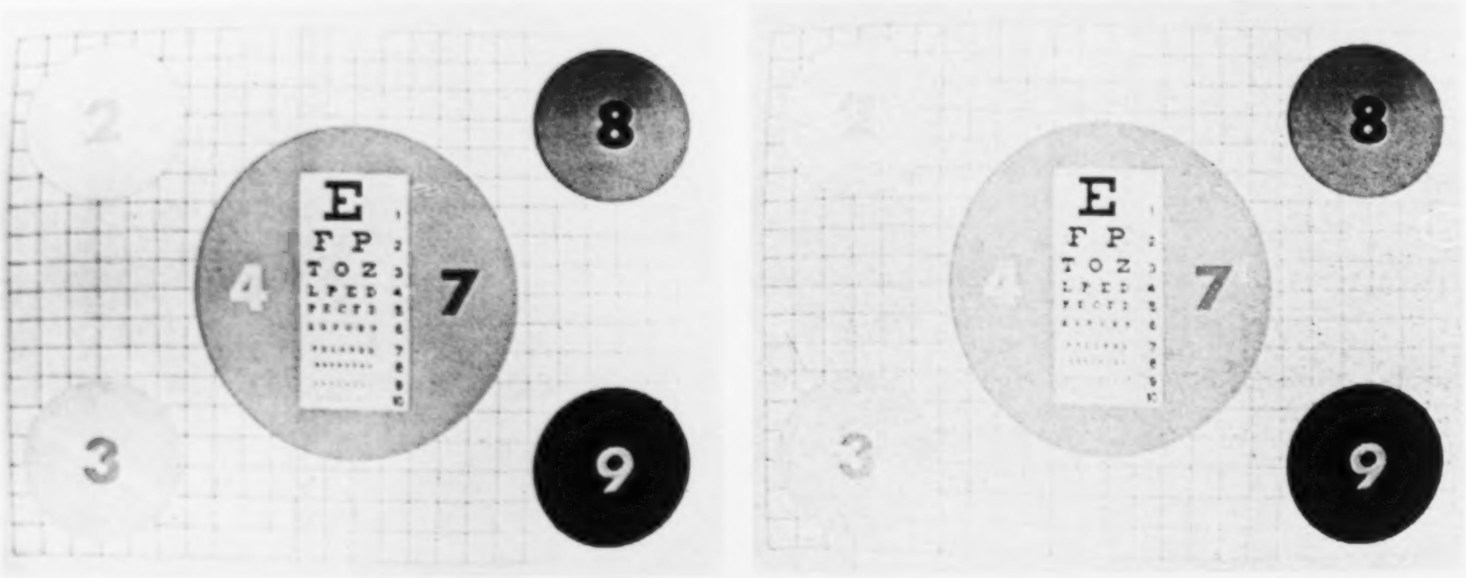
c. Standard picture, showing poor vertical linearity


2
8
E
F P
T O Z
4
7
3
9

d. Standard picture, showing poor horizontal linearity

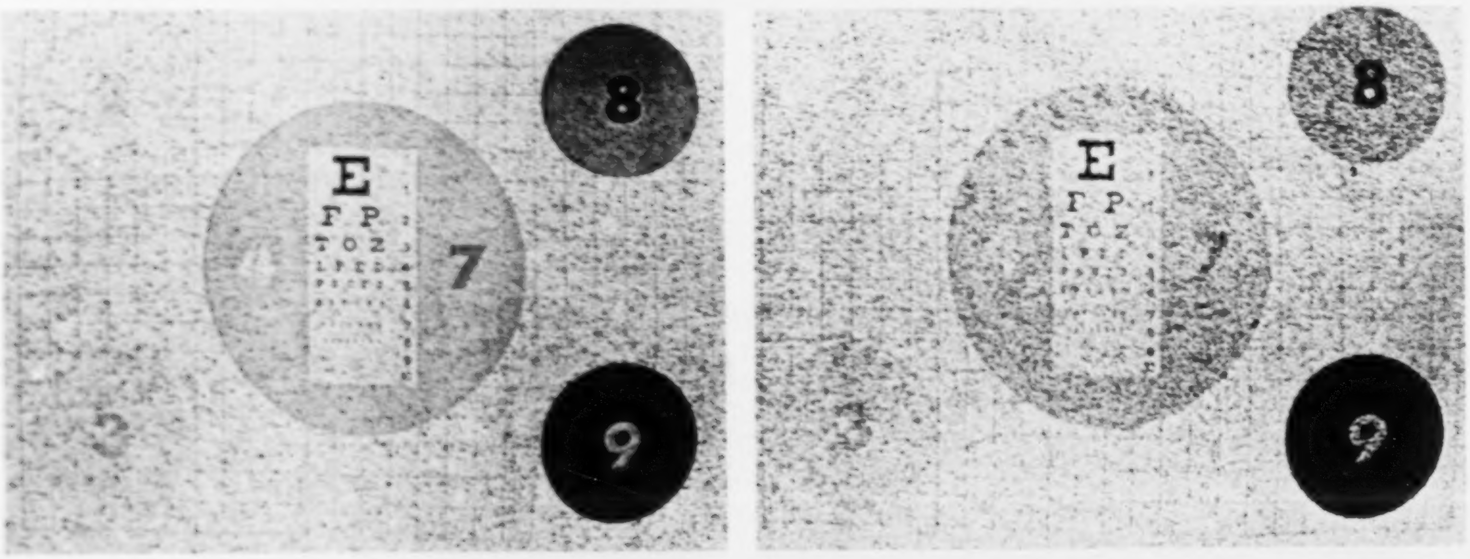
e. Standard picture, showing poor resolution

Fig. 5. Reproductions of the simplified test pattern as seen on a television screen—Continued.



f. Photograph of standard picture, from the TV screen, showing signal-to-noise ratio of 40 db.

g. Photograph of standard picture, from the TV screen, showing signal-to-noise ratio of 35 db.



h. Photograph of standard picture, from the TV screen, showing signal-to-noise ratio of 25 db.

i. Photograph of standard picture, from the TV screen, showing signal-to-noise ratio of 15 db.

BASIC DEFINITIONS

The purpose of this section is not to present a complete glossary of terms, since these are available in many convenient references,[6] but to introduce a few basic definitions with short explanatory comments to enable the reader to better understand what follows.

BROADCAST QUALITY.—A technical performance level meeting the minimum requirements for the broadcast services as set forth by the Federal Communications Commission (FCC) in the **Rules and Regulations.**

This definition warrants some discussion in that it has become an object of abuse and misuse throughout the television industry. FCC requirements or "FCC standards" are actually minimum requirements for the broadcast service, and as such do not necessarily constitute the highest possible standards of good engineering practice. Consequently, literal compliance with the minimum standards as set forth in the **Rules and Regulations** does not insure an exemplary technical operation. The fundamental point is that TV and radio equipment correctly classed as being of broadcast quality nevertheless exhibits a wide range of performance levels.

Furthermore, many FCC standards deal rather rigidly with requirements for the synchronizing signals, and give considerably less attention to the requirements of the picture signal. This is understandable since the FCC is insistent that the shape, timing, and temporal stability of these synchronizing signals be sufficiently uniform between different broadcasting stations so that the home receivers will display a picture without undue jitter, vertical "roll," horizontal "tearing," or "pairing" of the scanning lines.

The net consequence of this emphasis on the synchronizing signal is to insure that the average TV receiver is capable of displaying a stable picture, but the picture may not be worth watching because of impairments not treated in the rules. A typical—and appropriate—example of this may be found in some of the helical-scan tape recorders offered to educators as low-cost substitutes for the more expensive quadruplex[7] machines which are almost invariably used in TV stations. Some of these helical-scan machines are offered as meeting FCC broadcast standards. This may lead the potential customer to the belief that these machines perform as well as the quadruplex machines, while in fact it means only that the synchronizing signals meet the appropriate FCC standards. Furthermore, these minimum standards are generally not achieved inherently in the machine itself but usually through the use of an auxiliary "black-box" device (sometimes an integral part of the recorder) known as a processing amplifier which may cost a third as much as the video recorder. These devices perform the necessary improvements on the synchronizing signals with virtually no effect on that portion of the signal which influences the picture quality. In fact, under certain conditions, the use of such processing amplifiers can introduce impairments in the reproduced picture.

CABLE TELEVISION.—A method of delivering TV programs to homes, schools, classrooms, or other specific locations via cable from a central originating point. If this central point is a TV studio, the cable system is generally regarded as a closed-circuit distribution system. If the central point is a master antenna system capable of receiving multiple programs simultaneously from distant broadcasting stations, the cable system is generally referred to as a Community Antenna TV (CATV) system. Smaller systems restricted to serving apartments or classrooms within one complex are known as Master Antenna TV (MATV). The transmission cable, because of its design, is called coaxial.

EDUCATIONAL TELEVISION STATION.—A television broadcasting station, either VHF or UHF, technically identical to a commercial television station but devoted exclusively to noncommercial educational programing on channels reserved by the Federal Communications Commission (FCC) specifically for noncommercial educational use. The specific mission of such stations is to serve the instructional, cultural, and informational needs of the areas to which they are assigned. It is interesting to note that, although certain channels were reserved in 1952 for educational use, no channels are reserved for commercial use.

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[6] Some standard references are: Lewis, Philip. **Educational Television Guidebook,** New York: McGraw-Hill, 1961. 238 pp.; and Kessler, W. J. **Fundamentals of Television Systems.** Washington, D.C.: National Association of Educational Broadcasters, 1968, 80 pp.

See also **Through Cable to Classroom** by William C. Lewis, Washington, D.C.: National Education Association, 1967, 44 pp.

[7] These standard broadcast recorders are called "quadruplex" because they have four rotating recording heads.

ELECTRONICS INDUSTRIES ASSOCIATION (EIA).—As the name implies, EIA is one of the major electronics industries organizations. The Association is important because it has accepted the responsibility for establishing technical standards in many communications and electronics areas, including radio and television. Some standards bear the imprint of EIA's earlier names: REMA (Radio Electronics Manufacturers Association) and RMA (Radio Manufacturers Association).

HARDWARE.—The elements of equipment which are the component parts of the total physical system.

HERTZ.—A unit of measure corresponding to **cycles per second.** The term is frequently used with common prefixes to indicate larger units: kilohertz (kHz), 1000 cycles per second; megahertz (mHz), a million cycles per second; and gigahertz (gHz), a thousand million cycles per second.

INSTRUCTIONAL TELEVISION FIXED SERVICE (ITFS).—This is a television system which does not fit either the open-circuit or closed-circuit definition. It is properly described as a multiple-addressed fixed service, and was established by the FCC in 1963 exclusively for educational use. Since these systems operate in the frequency range between 2500 mHz and 2690 mHz, they are also commonly known as 2500 megahertz (or megacycle) systems. ITFS provides qualified educational applicants with a group of up to four TV channels, and also provides a degree of transmission privacy not possible in the broadcast service, since special receiving converters must be used at each receiving location. A complete description of this service may be found in the booklet **ITFS—What It Is . . . How To Plan,**[8] which was produced cooperatively by a number of interested agencies.

MICROWAVE.—A range in the frequency spectrum lying above 1000 mHz, commonly used for point-to-point communications through the use of highly directional transmitting and receiving antennas. For example, TV signals are commonly relayed from the station's studio to its remote transmitter site by microwave. These particular microwave units are known as Studio Transmitter Link (STL) systems.

SOFTWARE.—The information, or program content, which is being handled or transmitted by the physical system.

TELECOMMUNICATIONS.—Literally, communications over distance. A general term which is becoming accepted to include all known forms of electronic communication, including television, radio, data transmission, telephone, and teletype.

TRANSMISSION SYSTEM, CLOSED-CIRCUIT.—A system of transmitting or distributing telecommunications information, for example, TV pictures and sound or computer data over a wired system so that reception is limited to specific receivers connected to the system.

TRANSMISSION SYSTEM, OPEN CIRCUIT.—A system of transmitting or distributing telecommunications information over a broad area by disseminating electronic energy through space so that the information can be picked up on a receiver. The Federal Communications Commission does not officially employ the terms "closed-circuit" and "open-circuit" in its **Rules and Regulations.** Furthermore, the Commission exercises no direct jurisdiction over most closed-circuit systems as defined above. It recognizes two general operational categories known as 'broadcast" and "fixed" service. The broadcast service is that described above as "open-circuit," while the fixed services include such categories as point-to-point microwave systems and other nonbroadcast services.

TV TRANSLATOR.—A relatively small, low-power, inexpensive device that receives a TV signal from a distant TV broadcasting station, automatically converts the signal to another TV channel, and then rebroadcasts it. In this way, the station's range is extended or shadow areas are filled in.

ULTRA HIGH FREQUENCY (UHF).—As applied to television the UHF channels range from channel 14 through channel 83.

VERY HIGH FREQUENCY (VHF).—As applied to television, VHF channels are those numbered 2 through 13. Channels 2 through 6 are the "low-band" VHF group, and channels 7 through 13 are "high-band." There is no channel 1.

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[8] **ITFS—What It Is . . . How To Plan.** Washington, D.C. 20036: National Education Association, 1201 16th St., NW, 1967. 64 pp. Single copy free to administrators through the American Association of School Administrators of the NEA.

It is interesting to note that, in the VHF channel group, channels 6 and 7 are adjacent numbers but not technically adjacent channels. The gap between channels 6 and 7 contains all the FM broadcast channels, the aeronautical navigation and communications bands, and two-way communication services of various kinds. An even larger gap divides channels 13 and 14. These gaps or breaks in the TV assignment plan are responsible for significant performance differences among TV channel groups.

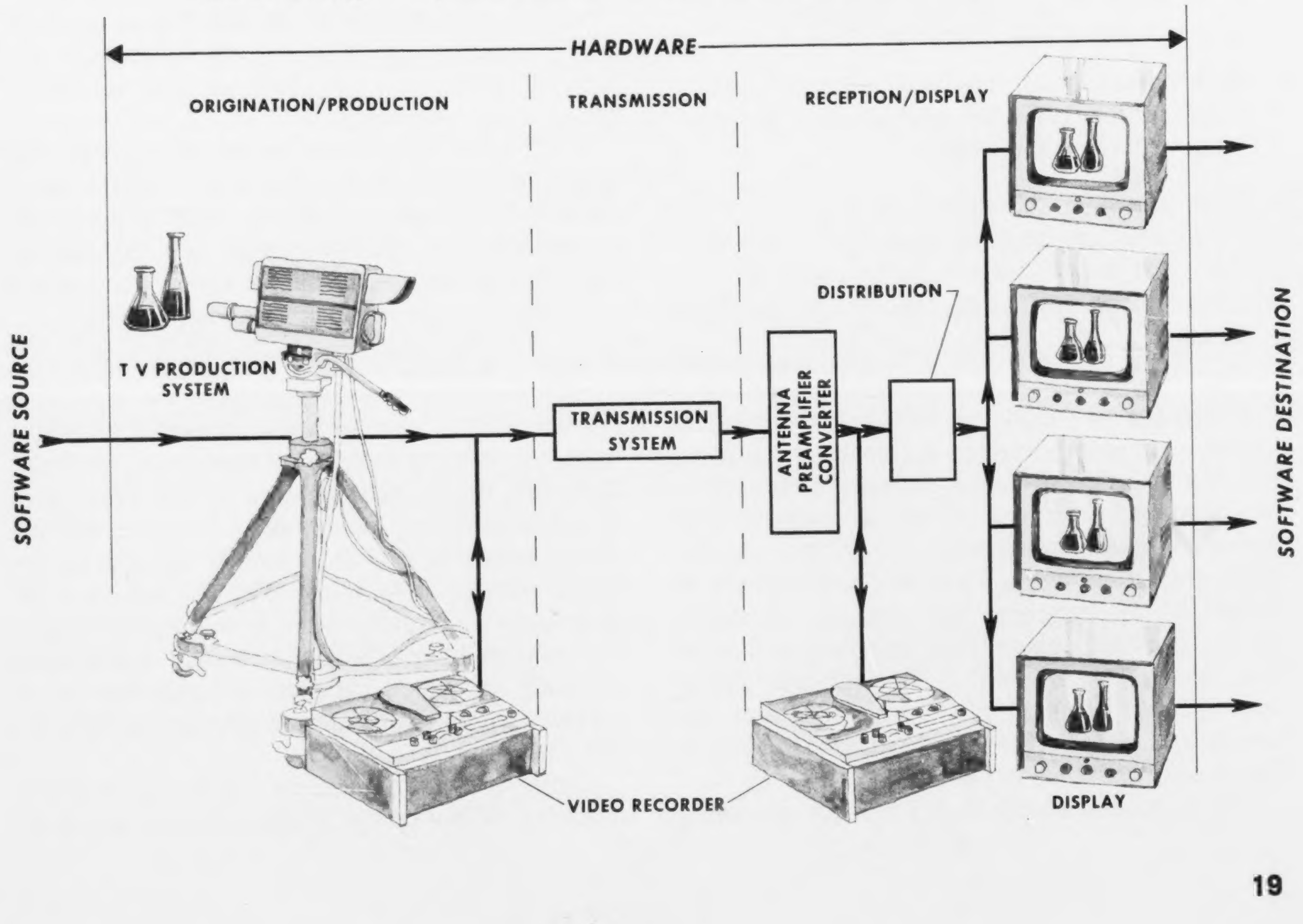
VIDEOTAPE RECORDING AND REPRODUCTION.—A method of storing video and audio television signals directly on magnetic tape in a manner suitable for immediate playback as often as required. An additional unique feature is that the stored programs can be "erased" easily to permit repeated use of the magnetic tapes.

THE BUILDING BLOCKS OF A TELEVISION SYSTEM

Having rooted about in the elements of television engineering, one can now begin to put these elements together to form a complete system.

Figure 6 is a simplified flow diagram of the three major parts of a complete television system: program origination, transmission, and reception. Also, prominently indicated is the omnipresent videotape recorder. The following chapters of this book treat, in order, these major building blocks and describe how practical, economical systems can be put together.

Fig. 6. Diagram of complete television system, showing how program information flows from its source through the production, transmission, and distribution systems.


HARDWARE
ORIGINATION/PRODUCTION
TRANSMISSION
RECEPTION/DISPLAY
SOFTWARE SOURCE
T V PRODUCTION SYSTEM
TRANSMISSION SYSTEM
ANTENNA PREAMPLIFIER CONVERTER
DISTRIBUTION
SOFTWARE DESTINATION
VIDEO RECORDER
DISPLAY

Chapter IV

TV PRODUCTION SYSTEMS

A LOOK AT A home TV set will demonstrate that television production takes place in various places: on football fields and city streets, at political conventions and beauty pageants, in classrooms and offices, and even in television studios.

When the production is successful, all of these places have certain important common elements in that there is–

1. Enough light for the operation of the cameras.
2. A place to put cameras and microphones so that the action may be followed appropriately.
3. A place to put control equipment, and where there is adequate electrical power.
4. An established means by which the persons responsible can operate the equipment with reasonable ease.

Other common characteristics could be found as one considers possible uses of his television system, but these four are inescapable. Do you want to cover a professor's talk in a lecture hall? Is there enough light? Where can cameras, microphones, and control equipment be placed? Is there enough power in the building, or must you find a generator? How can one be assured that cameras will see what needs to be seen, and that microphones will hear the important words?

These four elements or requirements must be met whether the program is the most carefully prepared drama or snap coverage of civil strife. However, there are variations. For example: Do you want to use television for teacher observation? In considering control you may decide to use small cameras, operated remotely so that the hardware will be inconspicuous and there will be no cameramen to distract the students. Or, suppose you want to observe psychiatric interviews? Be certain that equipment chosen is sensitive enough to operate at normal light levels and that placement of microphones will not affect the patient's responses.

Or, to take a large leap: Do you want a place for producing carefully prepared instructional materials–television materials that really concentrate on bringing the subject matter and the learner together? Make no mistake about it: you need a television studio, and nothing else will do.

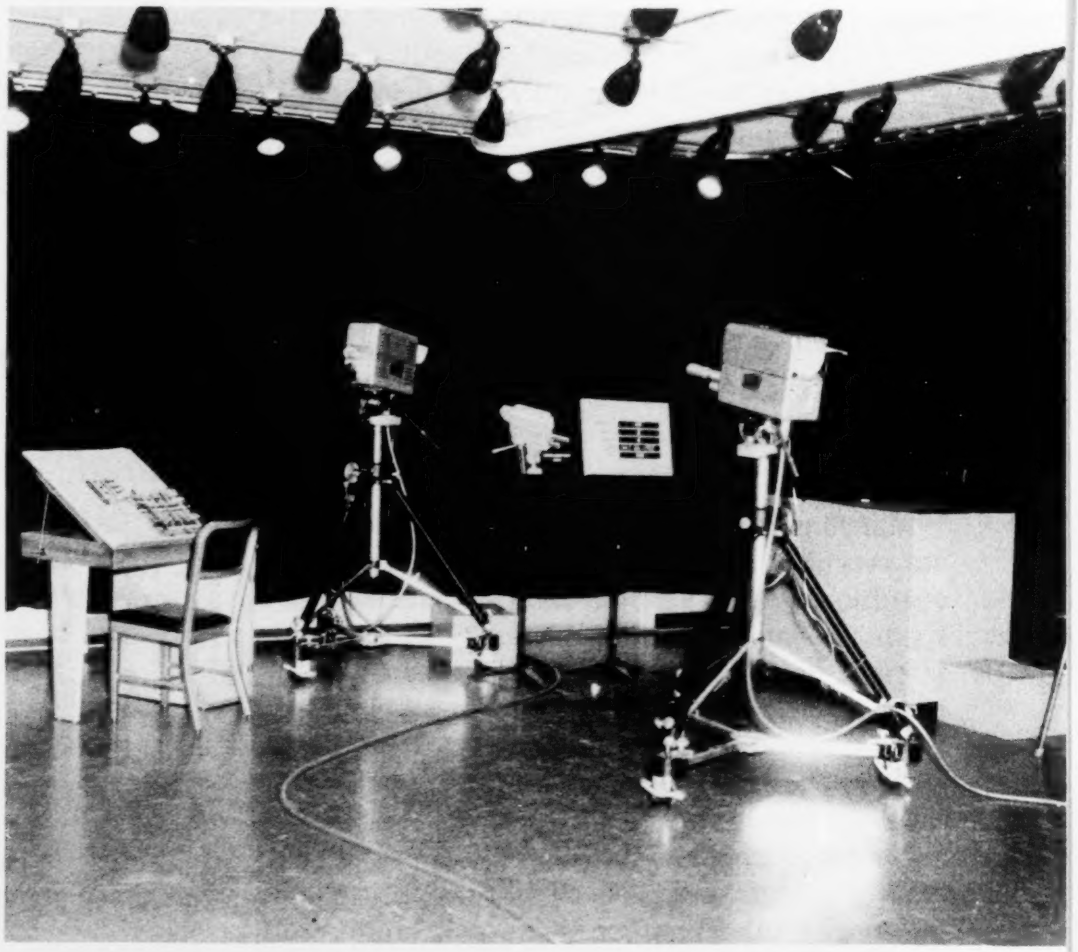
THE CONCEPT OF THE STUDIO

There are two kinds of television production: One fundamentally reports action as it happens; the other starts with the objective of communicating specific information, ideas, or attitudes, and the entire television experience is shaped towards those ends. (See figure 7.) Television that reports action is characterized by coverage of sports events, political conventions, parades, and such. The "shaped experience" is illustrated by television drama, commercials, newscasts, and the presentational varieties of instructional television. These are assembled in the studio.

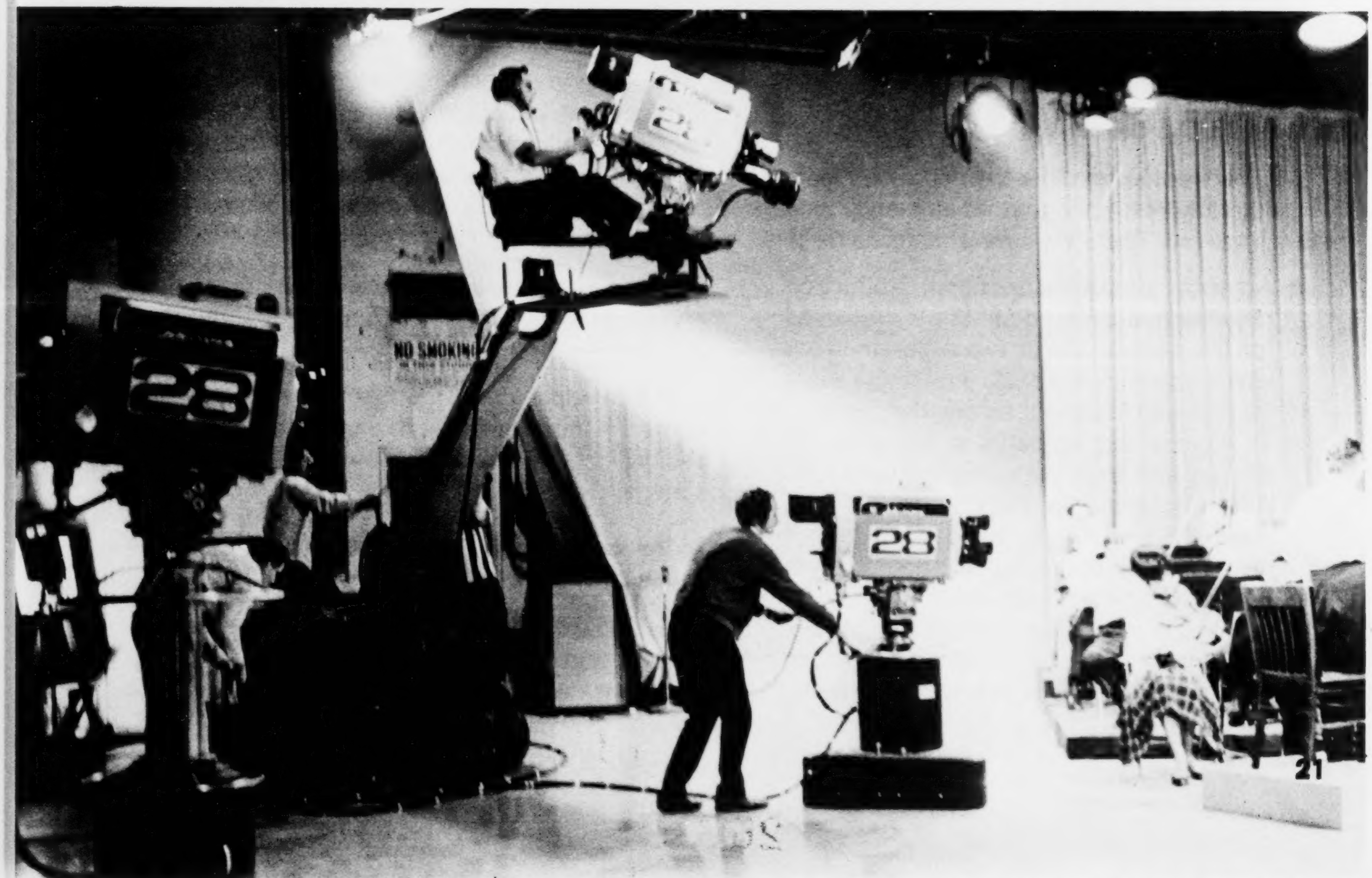
The television studio is a place for preparing flexible magic. It may house a simple stand-up lecture or castles in Spain. It can show a piece of sculpture in the best lighting it will ever have. It can impart the dynamics of a string quartet doing justice to Haydn. A simple set and painstaking lighting help bring alive the actor's presence as he illustrates a point from great literature. The science teacher's demonstration is shot with carefully rehearsed cameras to keep interest at a peak and communicate the principle exactly as intended.

Learning is influenced by the space in which it occurs. With a proper studio, one may approach

Fig. 7. a. Classroom converted to use simple studio equipment where the action is to be.



b. More complex equipment in major ETV station, where student performers are assembled.



the instructional problem by asking, "What should this experience accomplish?" Without it, he is back to using television merely to report what is in front of the camera. In many instructional situations, the result is a sort of public address system with pictures.

The studio meets the four requirements of adequate light, a place for cameras and microphones, a place for control equipment, and a capacity for control. But the studio pushes these requirements even further: Not just **enough** light, but the precise amount exactly where needed; not just a space for cameras and microphones, but an area in which they can move, a space in which cameras can see and microphones can hear just what is intended; not merely technical control, but a place in which many picture and sound sources can be orchestrated to do a carefully defined job and do it well; and finally, not just the ability to direct the use of hardware, but a facility in which a well-trained team can do its work.

STUDIO DESIGN REQUIREMENTS

Many instructional television installations operate very well without any studio; others are fully operational with a very rudimentary kind of studio space. If you have only modest production requirements, a well-lighted classroom may be all the "studio" you need.

A great many valid television uses do not imply any form of studio production. But if your objectives dictate a studio, and your architect is inexperienced in studio design, insist on competent help. Although television studio design is hardly the most complicated modern architectural problem, it offers an incredible number of traps for the unwary or uninitiated.

The following is not a discourse on how to design a studio. Rather, it is a list of some factors to be considered, written from the perspective of the television practitioner as he confronts instructional production problems.

Is there enough floor space?

When a studio is smaller than 40 by 50 feet, its use is greatly restricted and its efficiency is seriously impaired. There are several reasons for this:

- A typical simple instructional production requires one or two distinct playing areas for live action, one or two separate areas where graphics are shot, and ample room for camera movement among the areas.
- To light a set properly, a set must be several feet from the nearest studio wall. A small saving in construction cost is more than offset by the day-in, day-out delays and frustrations of attempting to light a studio that is too small.
- If there is more than one set in a studio, each set should be lighted so that no light spills onto other sets or studio walls.
- Cameramen must concentrate on their shots and not on studio traffic problems. Ample camera space represents money well spent.

Is the ceiling high enough?

If the studio lighting grid is less than 14 feet from the floor, someone should take a second look. Low ceilings cause virtually insurmountable lighting problems, and there should be adequate air space above the grid.

Is cabling for lights, cameras, and microphones designed so that the studio floor is not too cluttered?

Is there convenient access from the control room to the studio?

Contrary to popular opinion, a television director does not necessarily have to see the studio floor: the cameras are his eyes. But the director frequently needs to move between the control room and the studio, particularly in instructional production.

Is there adequate storage for such material as pieces of sets, graphics, and frequently used furniture?

If a hundred production people were asked to name the most annoying flaw in their own studio's design, at least 90 would complain about storage.

Is there outside access to the loading dock, the scene shop, and the driveway?

Ask your architect how he proposes to accommodate your need to drive a truck onto the studio floor. Are the studio doors high enough and wide enough to accommodate sets, furniture, vehicles, and all the bulky oddments that appear on television?

Is the floor flat?

One production requirement is to allow cameras to be moved while on the air, and any imperfection in the floor is greatly magnified in a joggled picture. Most people believe that the best studio floor is smooth concrete. Some standard educational specifications call for asphalt tile, which is satisfactory if several hundred pounds of camera or a couple of tons of automobile can roll over it without causing it to curl.

Is the studio isolated from outside noises, including the sounds from the control room and the "woosh" of the air-conditioning system?

Can the air conditioning system handle the load?

Since television lights generate a lot of heat, is the system designed so that the air flow will not disturb the sets or cause "false" noises to be picked up by the delicate microphones?

Are control room areas designed for efficient use of equipment?

Is equipment grouped for convenient coordination by technicians? Since few budgets are big enough to buy everything at once, is there enough space to accommodate growth?

Will control room air conditioning accommodate present and future equipment?

Although modern solid-state equipment runs much cooler than the older varieties, the equipment still needs the air conditioning even more than the people do.

Is the electronic maintenance facility reasonably convenient to the control rooms?

Breakdowns during production are frustrating, time-consuming, and extremely expensive. An investment in maintenance convenience will pay off in cold cash.

STUDIO EQUIPMENT

It would be convenient if one could say, "Here is what goes into a television studio and this is what it costs." But there is an enormous variety of equipment, manufactured for a great range of applications. One instructional television facility may be equipped more expensively than the local commercial TV station; another may at first glance seem very spartan; yet both may be properly equipped for their respective purposes.

Suppose that you have decided in a general way on the **amount** of equipment needed: **X** cameras, **Y** microphones, **Z** lights, studio switching system, audio control, film projection and control facilities, and videotape recorders. Since the range of available equipment is so great, it is essential to reevaluate precisely the intended uses of this equipment. Armed only with quantitative information, two purchasers can order from identical shopping lists and one may spend 15 times as much as the other.

Given full information about the respective intended uses of the two lists of equipment, two purchasers could buy the same **quantity** of equipment, both of them could purchase wisely, and yet one might spend 10 times as much as the other.

In comparing cameras, switchers, tape recorders, or other studio paraphernalia, one must become acquainted with the strengths and limitations of a given piece of equipment and understand the purposes for which it was designed. Part of this investigation must include quality of construction, performance reliability, ease of maintenance, and the ability and willingness of the vendor to provide effective field backup.

Television equipment, like other consumer products, is designed and manufactured in response to the indicated needs of particular marketing groups. If an educator (operating on an all-too-usual low budget) expresses a demand for low-cost television equipment that has compact dimensions and few maintenance needs and which may be operated by untrained personnel, manufacturers will try to respond. In meeting these demands, however, something has to give. The low price tag may bring with it low performance quality. Operational simplicity may also mean lack of flexibility. If on-the-job maintenance is not contemplated, the machine may be unduly difficult to repair.

Through it all, however, the manufacturers have presented to educators a range of equipment that meets almost every need. One unhappy result is that this wide choice constitutes a veritable electronic jungle which complicates the selection process. All too often, therefore, equipment choices are determined almost solely by the vendors' sales skill, assisted by low price tags. The result has been the acquisition of equipment and "systems" with capabilities bearing little or no relationship to the educational task at hand.

It is difficult to quarrel with the desire to purchase anything at the lowest possible price. However, a more useful approach would be to study the educational problem and then select television equipment that has the features needed, skips the frills, and provides a foundation for future expansion.

The really significant purchasing criterion is not the given item's price tag (large or small), or even how "good" it is, but the **ratio** represented by capabilities received for the money spent. Admittedly, it is no easy task to decide how much a given characteristic is worth. But in trying to decide, you at least approach an objective appraisal of the merits and demerits of a particular equipment item.

A short digression may help to illustrate. One common equipment item is the television camera, available in perhaps the widest capability and cost range. This was not always the case. Prior to the development of the low-cost vidicon TV camera pickup tube in 1950, most studio cameras employed the image orthicon pickup tube with the result that studio cameras of competitive manufactures exhibited similar characteristics and cost. Almost all TV pickup tubes used in film projection chains were iconoscopes. Life was then relatively simple for the equipment purchaser.

Then came the vidicon tube, with its initial low cost, long operating life, and low operating cost. These factors triggered the introduction of the "industrial television" era, creating a new generation of shoe-box-size television cameras intended for all sorts of industrial surveillance applications. To capitalize fully on the low cost of vidicon tubes in low-cost cameras, the manufacturers were forced to reduce the performance standards of the electronic circuitry and mechanical construction. This was a relatively simple matter, since the cameras were to be used exclusively in closed-circuit situations over which the FCC **Rules and Regulations** had no control. Furthermore, no performance standards for these applications had even been considered.

The great success of these cameras, costing less than $1,000, spurred the development of the vidicon camera for use as the TV pickup unit in studio film projection chains. This development was particularly appropriate since (1) the available iconoscope film chains were terrible, and (2) the main disadvantage of vidicon tubes, the need for relatively large amounts of light, could be overcome easily in projection systems.

At about this same time, educators were rapidly becoming aware of the potential of television as a modern educational tool. They created a demand for low-cost television equipment for experimental closed-circuit operations. Manufacturers took slightly improved versions of the industrial vidicon camera, and gave them electronic view finders. **Voila!** The market was served! It is only fair to say that the availability of these second-generation vidicon cameras did much to stimulate educational television growth in the early 1950's. As educators recognized the need for higher technical quality, manufacturers responded with higher-quality cameras, selling at higher prices, until vidicon systems that met minimum FCC broadcast requirements became available.

Educators now had to choose between the image orthicon cameras used by most commercial broadcasters and the vast array of vidicon cameras ranging from the cheapest industrial surveillance camera to a modern broadcast-type vidicon camera costing almost as much as its big-city image orthicon cousin. For the educator, the age of technological confusion was in full flower. Since that time, unhappily, things have only become worse.

The only way out of this thicket is to base decisions on sound educational objectives, scrupulously matching the equipment with its intended use. For example, vidicon cameras and image orthicon cameras are complementary, not competitive. They have their separate sets of advantages and limitations; in some ways they are hardly comparable. Here are a few specifics:

- Expensive image orthicon pickup tubes (up to $1,900 each) can be permanently damaged if pointed toward a high-intensity studio light. (Thus, inexperienced cameramen can be expensive.)
- Image orthicon cameras have a tendency to "burn" images into the photo emissive plate, and these burns may persist for some time. It is best not to use these cameras for prolonged looks at stationary scenes such as cards bearing sketches

and lettering. Vidicon cameras do not have this problem.

- Vidicon cameras exhibit "smearing" of moving highlights under lighting conditions that are less than optimum (and optimum is a lot of light). Thus, one cannot use vidicon cameras for such things as indoor sports events unless he can light them adequately. Otherwise, the viewers may see the trajectory of the moving ball as a white streak.
- Vidicon cameras are easier to operate than image orthicon cameras, and by and large are somewhat more rugged.
- Image orthicon tubes and vidicon tubes have somewhat different gray-scale response characteristics. Vidicon tubes actually produce a wider discernible range of grays. But most people like the relative "snap" and subjective clarity of the image orthicon picture, and consider the vidicon picture to be somewhat soft and washed out.
- A top-quality black-and-white image orthicon camera chain costs about $25,000. A top-quality studio vidicon camera chain costs about $15,000. The cheapest industrial surveillance vidicon is about $295. On the other end of the scale, the more expensive color cameras cost around $75,000.
- Vidicon tubes cost less than half as much as image orthicon tubes and last several times as long.

Which camera to choose? The decision must be based on educational objectives. The camera that is fine for one situation may be out of place in another for reasons that cannot be resolved into good and bad. Within affluent commercial broadcasting, for example, the inexpensive vidicon is almost universally used in film chains. In that situation, the vidicon's advantages shine brightly and its limitations can easily be overcome.

With variations, the same story could be told about many other equipment items. A switcher can be half a dozen push-buttons or a console capable of myriad special color effects. An audio control board may be a few switches and volume controls, or a complete system capable of reverberations, echos, and selective frequency enhancement. Lighting may be controlled by ordinary wall switches or by a complex system of dimmers, submastered for various studio areas and capable of several preset evolutions. Depending on what you want to do, any of these choices may be correct. In any case, however, it is best to make your purchase only after seeking expert advice.

Chapter V

TRANSMISSION SYSTEMS: GETTING THE PROGRAM FROM HERE TO THERE

AN EDUCATOR transmits his ITV materials by any of three means: (1) open circuit, on broadcast stations; (2) closed circuit, on cable systems of various kinds; and (3) the 2500 mHz Instructional Television Fixed Service.

The engineer might take a slightly different look at the alternatives. From his point of view, all known practical transmission systems may be initially classified either as radiation systems or as guided systems.

Radiation systems involve radiation of electromagnetic waves through space. In television, they include:

- Broadcast (open circuit) over VHF stations (channels 2 through 13) or UHF stations (channels 14 through 83)
- Microwave (highly directional point-to-point transmission)
- 2500 mHz ITFS (multiple-address point-to-point)
- Overhead satellite
- Laser communications beams, now under development

Guided systems involve the use of conducting materials to guide the signal along a specific route. Cable is usually used in this connection, but technically there are other possibilities.

Another look at the needs and goals is again necessary before choosing a transmission system. As considered below, ETV stations, the cable, and 2500 mHz systems are all very good answers, but to different questions.

ETV stations cover a large area with one channel. The addition of other channels depends on their availability and requires duplicate transmission facilities. ETV stations are intended to offer a diverse service to an entire region, and do not concentrate solely on instruction.

Cable systems come in many sizes, shapes, and costs. One kind of cable system distributes programs within a building, and another—the CATV system—distributes service to many homes for a monthly fee. There is sometimes a question of whether a cable system or an ITFS system will be most useful or economical in a given situation.

ITFS systems (2500 mHz) offer up to four channels of service at relatively low cost. They are reserved specifically for noncommercial instructional use, but they operate at low power and are intended to serve a relatively restricted area, such as a single school district or, at most, a small county.

EDUCATIONAL TELEVISION STATIONS

Broadcast stations are either VHF (channels 2 through 13) or UHF (channels 14 through 83). A number of channels have been reserved specifically for noncommercial educational use, and in a few areas of the country it is still possible to secure a nonreserved channel. As a practical matter, most remaining channels—except in certain sparsely settled areas—are UHF.

It is easy to find out whether there is an available channel reserved for educational use in your area. The official source of the information is the FCC table of assignments listed in Part 73.606 of the FCC **Rules and Regulations.** Perhaps more convenient are several annual references such as the **Broadcasting Yearbook,** published by Broadcasting Publications, Inc., Washington, D.C., and **Television Factbook,** published by Television Digest, Inc., Washington, D.C. Either may be available at a public library.

If there is no noncommercial educational reservation, then it is important to know that the FCC has provided machinery whereby one may petition to reserve other channels. Furthermore, TV channels not reserved for education are not automatically reserved for commercial interests.

In the event the allocation table shows no available channels in your area, an engineering study may reveal ways in which another channel may be "dropped in" by the Commission upon demonstration of need.

But before becoming bogged down in channel selection mechanics and the arduous task of assembling an ETV station application, it will be well to remember that an ETV station is more than an instructional device. Such a station is responsible for providing informational, cultural, and educational services to home viewers. It is designed to serve all educational levels, its scope as broad as the problems and needs of the entire geographical area it covers.

Educational television stations, then, have a somewhat different mission than installations which are purely for in-class instruction. An educational administrator who seeks to solve a primarily instructional problem must confront that fact carefully. Several school systems—that of Denver is a notable example—have accepted the challenge of full ETV station operation.

Numerous factors revolve around the VHF-UHF problem. Most of the established, popular, network commercial stations are VHF. Even though all sets manufactured since 1964 have been UHF-equipped, people have been in no great hurry to put up UHF antennas, and many with relatively new sets are not even aware that they can receive UHF. One prevailing misconception is that an adapter is needed to receive educational stations. Conversely, some struggling commercial UHF stations are constantly frustrated by the people who assume that since the station is UHF it must be educational. The situation is worsened by the fact that some set manufacturers have not been particularly enthusiastic about including UHF capability in their low-cost receivers, and this apathy is often reflected in the quality of their UHF design.

As more stations go on the air and as the audience becomes acquainted with UHF station services—both commercial and educational—this confusion will hopefully fade away. However, the administrator who now contemplates establishing an ETV broadcast station should find help in the answers to some specific questions that follow.

Is your area served by existing UHF or VHF stations, or a combination of both?

If an area is already served effectively by one or more UHF stations, your potential audience may already be accustomed to using the UHF band on their TV sets. But if the area has, say, one independent UHF station and a number of VHF stations (which probably have the network affiliations), UHF may still be a stranger in most homes.

If the area is presently served only by VHF stations—and you contemplate adding a UHF educational station—you may be in for a frustrating and lonely time. You can have a gala inaugural broadcast, attended by all the right people; you can put on publicity campaigns that you cannot afford; you can present programs that make you proud to be in television; yet an overwhelming number of people still will not know you are there; a discouraging number will not even care.

If an existing service is provided primarily by VHF stations, how many area receivers are equipped for UHF?

People who have bought television receivers since 1964 can hardly avoid having UHF, since manufacturers are now required to include UHF capability in their sets. Nevertheless, some accurate idea of the potential UHF audience is needed.

Even though a large number of UHF receivers may exist, how many are actually equipped with a UHF antenna?

Having UHF on a set and being able to receive UHF are two different matters. The handsome new portable will have built-in rabbit ears that are not connected to the set's UHF tuner. For UHF reception, a small wire loop is attached to the back of the set—if it was not inadvertently thrown away or dismissed because you did not know what it was.

Even if a set is equipped with an indoor antenna, and even if you are not too far from the station's transmitter, the picture may be flawed by nearby buildings or hills. A proper outdoor antenna can help. UHF antennas are especially convenient to mount because they are much smaller than those used for VHF.[1]

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[1] Antenna size is related to the size of the wave to be received. The higher the frequency, the shorter the wave. UHF waves, thus, are shorter than VHF; and UHF antennas are smaller.

If the area is already served by a UHF station, would it be possible to construct the new educational transmitter on or near the existing UHF transmitter?

Why should you locate your UHF transmitter on the same site as other UHF stations?

This should be done so that viewers at home can point their antennas in one direction and receive all available UHF channels. Such cooperative arrangement usually benefits all concerned.

Schools are hardly affected by this VHF-UHF problem, since most of them add television antennas, distribution systems, and receivers only with the advent of the educational television station, and thus it is of no particular consequence whether the station is UHF or VHF.

The following summarizes the characteristics of ETV stations:

1. Educational television stations are technically identical to any other television stations, operating either on VHF or UHF channels. Most new stations will be UHF, and this is a source of some practical frustration.

2. Educational television stations, unlike more specialized operations, have a responsibility to serve the diverse interests of an entire geographical region. Instruction is generally a major part of but by no means the whole task.

3. Television stations operate at high power over a broad geographical area, with a service diameter commonly in excess of 100 miles.

4. Television stations operate just one channel, while instructional loads and scheduling problems may make multichannel capability an important factor.

CABLE SYSTEMS

Within the scope of this publication two kinds of cable systems are considered for education. The one contemplated in this section is the citywide or districtwide system that would be an alternative to broadcast or to 2500 mHz ITFS systems. The smaller cable systems, serving intra-building or intra-campus, will be discussed in chapter VI.

Briefly, the following characterizes these larger cable transmission systems:

- They are inherently multichannel, since they invariably use the technique called RF (radio frequency) carrier transmission. See further discussion of this in chapter VI.
- The size of the system is limited by factors which have no bearing on the radiation system limitations.
- Since they don't depend on assignment of frequencies by the FCC, you can use as many channels as you can afford, with no limitations imposed by the lack of space in the electromagnetic spectrum.

A cable system can be acquired in either of two ways: (1) Build, maintain, and operate your own, or (2) lease service from the local phone company or from another carrier such as a CATV company.

CONSTRUCTION COSTS.—The major cost of constructing a television cable transmission system is labor. Cable must be strung, and reamplifiers must be installed every 1,000 to 3,000 feet, depending on the particular design.

As with power or phone lines, cable may be strung on poles or laid in underground systems. By and large, overhead cable costs less to install and underground cable costs less to maintain. Underground costs vary so much that no meaningful guidelines can be devised for the whole country. Some financial rules of thumb for aerial systems will be discussed below.

The present state of the art limits the number of reamplifiers that may be installed on a cable. Depending on cable length and amplifier spacing, this number may be as few as 50, and it will seldom exceed 150. The result of these limitations is that cable runs are limited to about 30 miles.

This does not mean that an installation cannot extend more than 30 miles, but only that the system's originating point should be within 30 cable miles of any particular destination. In larger systems, the originating point is placed near the center of the service area so that greater reach may be achieved. Even in smaller systems, it is still wise to place the origination point near the middle, since shorter cable runs mean less cost and higher performance.

The costs of overhead aerial cable systems—at least those of reasonably large size—are generally proportional to cable mileage. A reasonable estimate of construction costs for a user-owned system is $4,000 per mile. This takes into account such costs as cable, messenger cable, fittings, amplifiers, new construction, and labor. The actual range of costs, based on figures late in1968, is likely to be $3,000 to $5,000, with $4,000 as a reasonable nationwide average.

This cost formula assumes the use of existing utility poles (power or telephone) as cable supports. Commercial CATV organizations usually pay a yearly rental fee of $150 to $200 per mile of pole supports. Since the poles are used primarily for public utility purposes, it is probable that pole space for schools could be had for a very low rate, or even free.

The annual maintenance and operating cost of a school-owned cable system could be expected to range from as low as 5 percent to as high as 10 percent of the initial capital outlay. Thus the complete cost formula where **N** is the number of cable miles and **M** is the number of years, becomes:

$$\text{Total cost} = \mathbf{N}4000 + \mathbf{NM}400 + \mathbf{NM}200$$

LEASE COSTS.—Equivalent cable transmission service may be leased from the local telephone company or perhaps from CATV systems. Since the leasing rates of the phone companies are regulated by State utility commissions, the local phone company is the best source for information applicable to a specific area. However, rate structures are sufficiently uniform across the United States that a reasonable valid cost equation may be formulated. Lease costs are based on:

- Number of channels
- Number of cable miles
- Recurrent monthly lease charges
- Nonrecurring initial channel charges and school connection charges

Thus, a leased system involves only a slight capital outlay and no periodic maintenance and operating costs. One regular bill pays for the entire transmission operation.

A direct cost comparison between a school-owned and a leased system is not entirely practical, since the cable installation is inherently multichannel and the "equivalent" leased service is dependent on the number of channels ordered. Recognizing that some sort of comparison is necessary, particularly when one must subsequently compare the costs of cable and ITFS, the following equation may be useful for estimating annual lease costs from the telephone company:

$$\text{Annual cost} = \mathbf{N}1248 + \mathbf{p}15$$

N equals the number of airline miles from the origination point to the most remote destination point, and **p** is equal to the number of schools served by the leased service. A four-channel leased service is assumed. In the first year an additional amount of $1,560 should be added to the estimate because of one-time construction charges.

Application of this cost formula is valid only within the local exchange area of the telephone company involved.

Either school-owned or leased cable facilities offer distinct technical advantages—and perhaps economic advantages—when a relatively small area characterized by rugged terrain must be considered. Such terrain may create severe propagation problems for broadcast or ITFS systems. These factors may offset the relatively high cost of cable.

This is but another indication that the various transmission systems discussed in this chapter are not competitive or "equal alternative" systems that can be evaluated by studying price tags alone.

From time to time, possibilities are raised about using ordinary CATV systems as a version of a cable transmission system for schools. CATV systems commonly provide free service to schools; that is, they provide their regular service to schools at no charge. This regular service consists of a single connection which provides all channels—commercial and educational—carried by the local CATV system. Distribution of the service within the school, reasonably enough, is usually the school's problem. Some CATV systems also provide an empty channel so that schools may distribute educational materials.

The availability of CATV service at the school is clearly a useful gift, particularly in fringe areas. There are, however, at least two matters that should not be overlooked:

1. Internal distribution of the signal is probably still the problem of the school. Without

an adequate distribution system, the generous gift of the CATV system is lost.

2. Not all CATV systems provide really adequate signal strength. It would often be simpler and better to simply put an antenna on the roof.

In examining the possibility of a "private" CATV channel for school use, other factors should be considered as well:

1. Does the franchise area of the CATV system cover the district, or will certain schools lie outside the coverage pattern?

2. The free channel is probably a spare, offered on a "space-available" basis. As the cable company grows, will the channel still be available? Free?

3. It will probably be your problem to deliver the television signal to the "head-end" equipment of the CATV system. How will you get it there?

In spite of these questions, the fact remains that CATV systems are growing rapidly in coverage, technical competence, financial strength, and management sophistication. They are rendering valuable service to many schools, and will assume an ever-increasing role in the American communications complex. They should not be dismissed lightly as you make your ITV plans.

INSTRUCTIONAL TELEVISION FIXED SERVICE

These 2500 mHz systems have developed by leaps and bounds since the service was created by the FCC in 1963. The following are among their characteristics:

- Multichannel capability
- Point-to-point radiated transmission from a central location to several schools
- Low power for restricted coverage

In a sense, ITFS borrows from broadcasting and from cable services. It uses broadcast-type radiation techniques, but at low power. Licensees may secure up to four channels from the FCC. The signals cannot be received on ordinary TV sets without ITFS converters, and so some privacy is assured. Like cable systems, they are intended for relatively small areas. (See figure 8.)

Low power is one of the central facts of ITFS. While a UHF educational TV station may radiate upwards of a million watts of power, ITFS transmitters are held to 10 watts. This fact is not necessarily a drawback. The 10-watt power limitation, combined with extremely sharp line-of-sight transmission characteristics, means that ITFS systems can be controlled very precisely. Another system using the same channel group can operate without interference only 15 or 20 miles away.

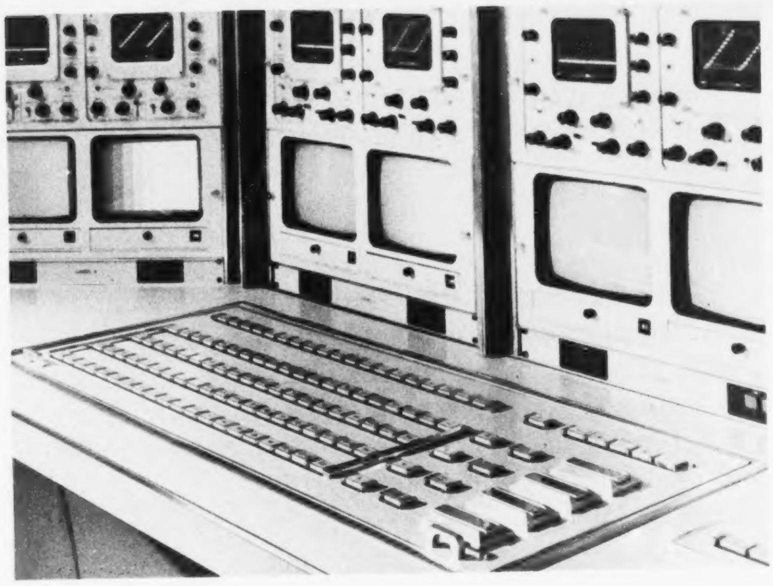
The reach of the system can be predicted quite accurately. An elevated transmitting antenna will reach a distance in statute miles that is about 40 percent greater than the square root of the elevation in feet above the terrain. For example, an antenna 200 feet high will provide a line-of-sight horizon distance of 14.14 (the square root of 200) times 1.4, or approximately 20 miles. Beyond the horizon, the signal drops off very rapidly.

One of the major problems facing the decision-maker when considering an ITFS system is rooted in the expansive coverage claims made by some of its proponents. In analyzing these claims, one must recognize that television signals weaken gradually with distance, and thus the picture quality on the receiver also deteriorates gradually. The useful service range of any TV transmission system, then, depends on what is considered acceptable quality. For example, what picture-to-snow ratio are you willing to accept? If you insist on relatively high classroom reception standards, you may find that those ebulliently proclaimed service areas shrink drastically.

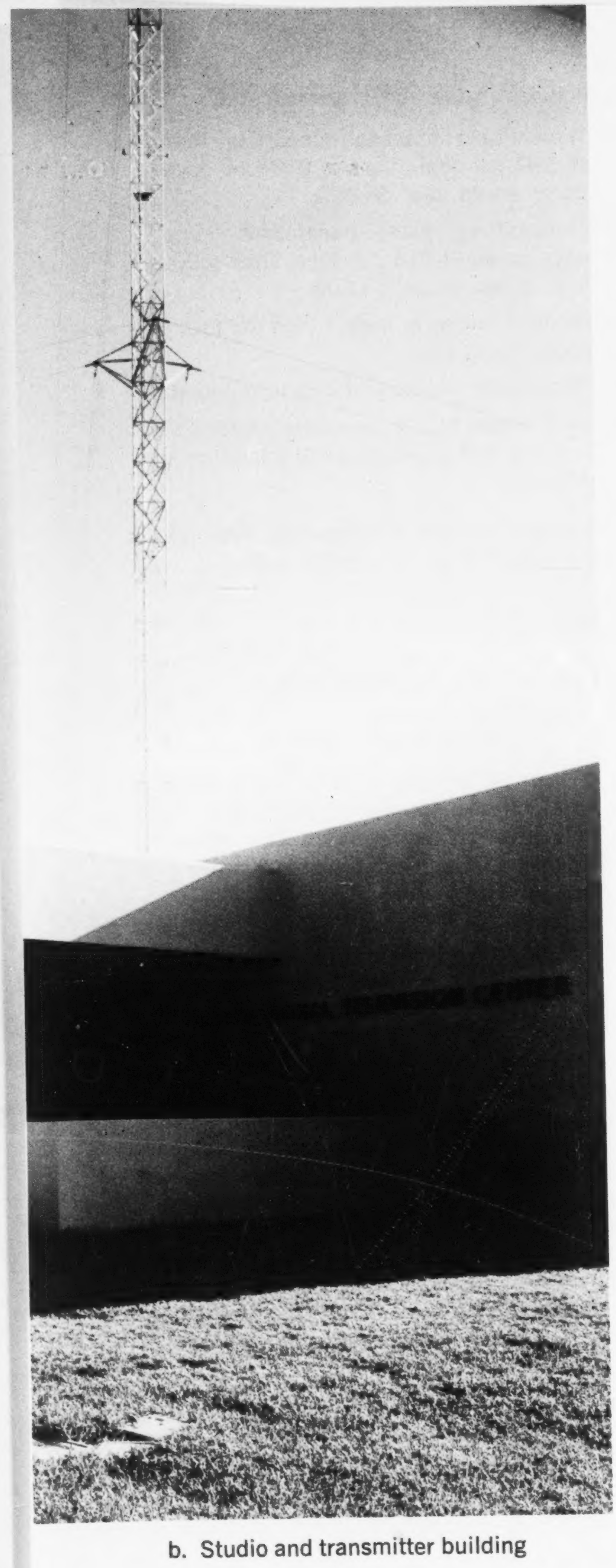
Similarly, large projected service areas can sometimes be traced to engineering designs which called for impractically large receiving antennas to be placed at the top of absurdly tall towers in order to overcome losses from earth curvature, tall trees, hills, and buildings along the path between the transmitter and the receiving site. Terrain problems, incidentally, are particularly frustrating to ITFS planners. The high frequencies used in these systems have even less "bend" than ordinary television signals. Hills, buildings, and groves of trees cause sharp shadows in ITFS coverage. Design ingenuity can overcome some of these troubles, but they can never be ignored.

In addition to its multichannel availability and the essentially "tailor-made" nature of ITFS systems, cost is one of the most attractive features.

Fig. 8. Instructional Television Fixed Service Facility, Fort Lauderdale (Broward County), Florida.



a. Switching facilities



b. Studio and transmitter building

c. Scene in studio: listening booths for preview by producers and teachers are equipped with re-winds, sound readers, viewers, counters, turntables, and tape recorders

As in many engineering areas, it is possible to give some reasonably accurate estimates. If carefully applied, the following formula should produce a good estimate of the likely costs:

Cost in dollars $= \mathbf{A} + \mathbf{mB} + \mathbf{nC}$
$\mathbf{A} =$ Cost of the first ITFS transmitter complete with transmitting antenna plus usual fittings, at $15,000
$\mathbf{B} =$ Cost of additional (up to 3) transmitters for desired additional ITFS channels, plus usual fittings, at $10,000
$\mathbf{C} =$ Cost of each school's receiving installation at $1,500 each, consisting of one 4-foot parabolic antenna and down converter with 20-foot antenna support
$\mathbf{m} =$ Number of additional ITFS channels
$\mathbf{n} =$ Number of school-receiving locations

Not included in the above estimates are:

- Transmitting antenna supporting tower at $30 per foot. Thus a 200-foot guyed tower would cost $6,000.
- Transmitting plant transmission line/wave guide at $15 per foot. Thus a 200-foot run would cost $3,000.
- Antenna supports higher than 20 feet at school locations.
- Transmitter building, if one is required.
- Land areas to accommodate transmitter building and guyed tower, if this must be acquired.

The average annual maintenance cost equals about 10 percent of the capital outlay.

COMPARISON OF SYSTEM COSTS

A comparison of the relative costs of different transmission systems must begin with the ground rule "Other things being equal . . .," although they seldom are. The attempt here is to make things as equal as possible by comparing costs as applied to one carefully defined school district.

With geometric precision not found in real life, our model consists of a school district in which 32 schools are uniformly distributed along eight radials from a central origination point. (See figure 9.)

In order to make any sense at all, the broadcast system should be dismissed from the comparison. There are a number of reasons for this. First, the broadcast system is intended to serve a relatively large geographical area. Second, it is essentially a one-channel system unless another channel is available to virtually duplicate the transmission hardware. The cable and ITFS systems are functionally similar enough to compare, whereas the broadcast station is wholly different.

To be compared, then, are a school-owned cable transmission system, a four-channel leased cable system, and a four-channel ITFS system:

For the school-owned cable transmission system:

Total cost in dollars =

$$\mathbf{N}4000 + \mathbf{NM}400 + \mathbf{NM}200$$

For the four-channel leased cable service:

Total cost in dollars =

$$1560 + \mathbf{p}15 = \mathbf{NM}1248$$

For the four-channel ITFS system:[2]

Total cost in dollars =

$$45{,}000 + \mathbf{p}1500 + \mathbf{M}(4500 + p150)$$

In these equations, **N** is the number of miles, **M** the number of years, and **p** the number of school locations. The values for **N** and **p** in this idealized system are:

$\mathbf{N} = 160$ miles
$\mathbf{p} = 32$ schools

In working out the equations and plotting the results for a 10-year period, one finds the rather dramatic results shown in figure 10.

These results are for one single model system only, and for the sake of comparison, the many differences have been pruned as much as possible. Thus, these formulas ignore the fact that, for example, an owned cable system could be designed to provide transmission **from** schools as well as **to** them, and that such systems could carry other services in addition to television. These services might include administrative information in hard-copy form, feedback from classes to the TV studio, computer signals, or any of several other services.

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[2] Not included in the ITFS formula is the cost of a transmitting tower, a wave guide run, receiving antenna supports in excess of 20 feet, and buildings and land. These are all highly individual variables, since the existence of one centrally located tall building will minimize them all.

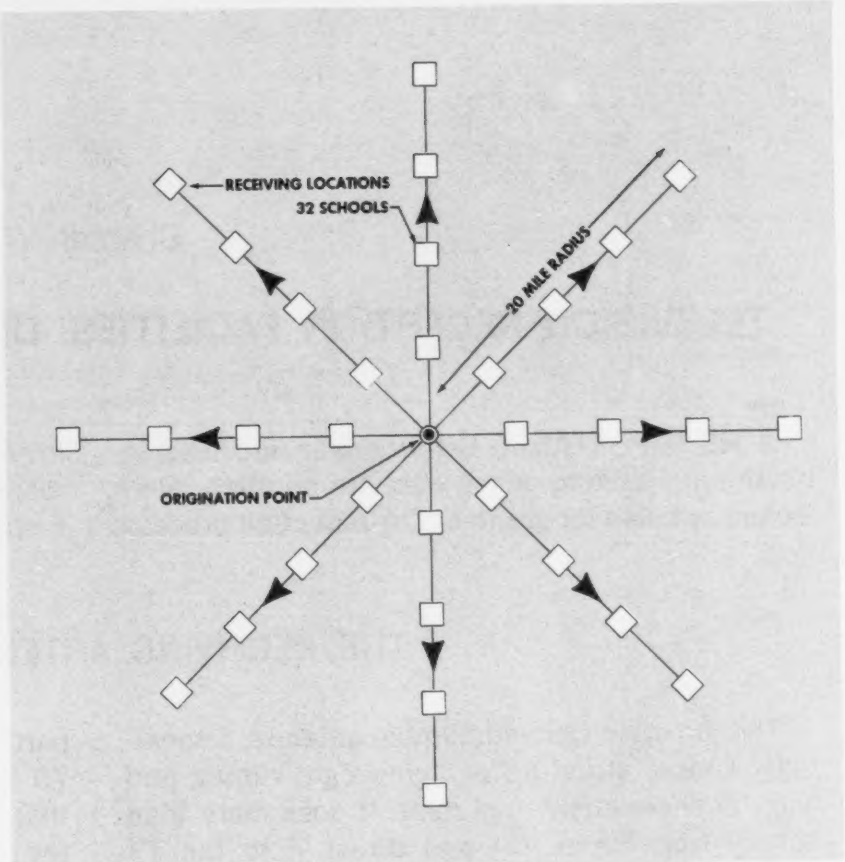
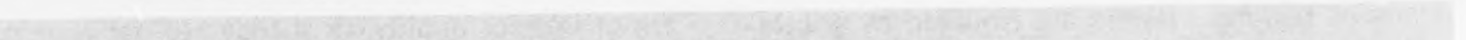

RECEIVING LOCATIONS
32 SCHOOLS
20 MILE RADIUS
ORIGINATION POINT

Fig. 9. Idealized model showing television receiving locations of 32 schools over a 20-mile radius served by a single origination point for comparison of transmission costs in figure 10.

Fig. 10. Comparison of transmission costs between school-owned (private) cable transmission, four-channel leased cable, and four-channel ITFS systems, over a 10-year period, based on model in figure 9.



Chapter VI

TELEVISION RECEPTION FACILITIES: DELIVERY TO THE CLASSROOM

THE IMPORTANCE OF reception facilities is worth emphasizing, since they are so often overlooked or taken for granted. The reception process may be divided into three distinct elements: the receiving antenna, the in-school cable distribution system, and the television image display devices.

THE RECEIVING ANTENNA SYSTEM

The too often ignored humble antenna, a seemingly simple structure of lightweight tubing and wire, is enormously important. It does more than simply trap the signal and direct it to the TV set. In areas of strong TV signals, simple rabbit ears will probably be sufficient from a purely "signal-capturing" standpoint. Unfortunately, this is not the whole story. In urban areas and mountainous regions, viewers are troubled by ghosts—multiple TV images caused by reflected signals that arrive at somewhat different angles from the basic transmission.

Ghosting may in fact be a problem even when the ghost is not readily visible. A ghost almost too small to notice can cause a serious drop in the resolution. The problem may not be identified as ghosting, but you will know that the quality is not what it should be.

Since the signals that cause ghosting arrive at different angles from the basic transmission, the solution to the problem is the use of a highly directional antenna. This antenna can be carefully oriented toward the stronger direct signal to accentuate the positive (the sharp, high-resolution picture) and eliminate the negative (the ghost).

One of the most effective keys to good reception, then, is an antenna that is well chosen, carefully mounted, and kept in good condition.

THE PREAMPLIFIER.—Outside antenna systems operating in fringe reception areas frequently need a preamplifier. These are normally mounted immediately adjacent to the antenna, particularly if the antenna lead-in is longer than 75 feet. The reason for the awkward location is that the antenna lead-in wire seriously weakens the signal by the time it reaches the receiver. The idea, then, is to boost the signal enough that it can survive the trip and arrive at the receiver sufficiently strong to do the job.

A word of caution about preamplifiers: If they are of inferior quality, or if they are not working well, they are literally worse than none at all. This is particularly true when receiving UHF signals.

THE CHANNEL CONVERTER.—Channel converters (sometimes just called converters) are used quite frequently for UHF reception and always with 2500 mHz ITFS systems. As their name implies, these devices convert an incoming signal from one channel to another. Converters are generally located next to the antenna so that the UHF or ITFS channels are converted to the lower VHF channels immediately, before the signal is sent down the antenna transmission line. These lead-in lines almost always exhibit extreme losses at the frequencies of UHF broadcast stations or ITFS transmissions.

If converters are to generate stable signals, they must be designed, built, and installed to withstand environmental extremes. Otherwise, the converted signal will be unstable when it appears on the VHF channels of classroom receivers, and teachers all along the system will distract students while they fine-tune their classroom sets.

THE IN-SCHOOL CABLE DISTRIBUTION SYSTEM

The antenna captures the television signal and, perhaps in association with the hardware noted above, delivers it to the input of the local distribution system. This system takes the TV signals to classrooms or other designated points.

Television cable distribution systems as discussed in this section are different from the much larger television cable transmission systems considered in chapter V. Trunk lines extend less than 2,000 feet and thus do not generally employ reamplifiers. The large transmission systems may have trunk lines as long as 30 miles, thus making frequent reamplification essential.

Technically, cable distribution systems fall into one of two categories: either direct video systems or modulated RF systems.

DIRECT VIDEO DISTRIBUTION SYSTEMS.—Television cable distribution systems of the direct video type are designed to distribute the video picture signal and its synchronizing pulses in much the same way that signals are routed within large TV production centers. Coaxial cables in these systems act almost like hoses connecting **one** picture source to **one** classroom position. These systems can handle only one video signal at a time and require the use of a separate line to carry the sound. Switching between programs is done at a central place with a TV audio/video switcher.

A most important restriction of direct video systems is that they are limited to trunk-line lengths of not much over 1,500 feet unless elaborate equalizers are installed at frequent intervals to avoid losses in high-frequency response and hence a loss of detail on the picture monitor.

Direct video systems usually do not use ordinary TV sets in classrooms, but rather make use of monitors like those used in TV control rooms. Sound is heard through auxiliary speaker systems. Thus, a direct video system, well designed and properly installed, is capable of much higher picture and sound quality than can be received at home.

A typical configuration for a direct video distribution system is shown in figure 11. Note that the configuration minimizes trunk-line lengths, so that they may be kept well within the 1,500 to 2,000 feet limitation.

Direct video distribution systems have the following characteristics in that they—

- Provide the highest distribution quality now attainable
- Require the use of studio-type video monitors for classroom display,[1] the monitors also contributing to the high overall quality
- Are subject to technical problems such as interference from power distribution facilities, particularly on long cable runs
- Require separate audio distribution lines and classroom speaker systems to distribute the sound.
- Require additional coaxial cables installed at additional expense if the classroom teacher is to be given the options of switching his set from one program to another

Direct video systems are generally employed only where the distribution system is confined to one building and where the requirement for the highest possible quality justifies the additional cost.

MODULATED RADIO FREQUENCY (RF) SYSTEMS.—Modulated RF distribution systems make use of a head-end device known as an audio-video radio frequency modulator. These modulators, essentially ultra-low power VHF television transmitters, are about the size of a shoe box, delivering an output power of no more than a hundredth of a watt. This low power is applied directly to the cable distribution system for classroom distribution on any convenient VHF channel. Since the sound and picture are combined by the modulator to form a standard VHF television signal, conventional TV receivers may be used in the classroom with the VHF channel selector set to the appropriate channel. Present technology permits "stacking" and distributing up to 12 channels.

No FCC license is required to operate these miniature transmitters, since the signal is delivered to classrooms in the confines of a shielded cable and no significant radiation takes place.

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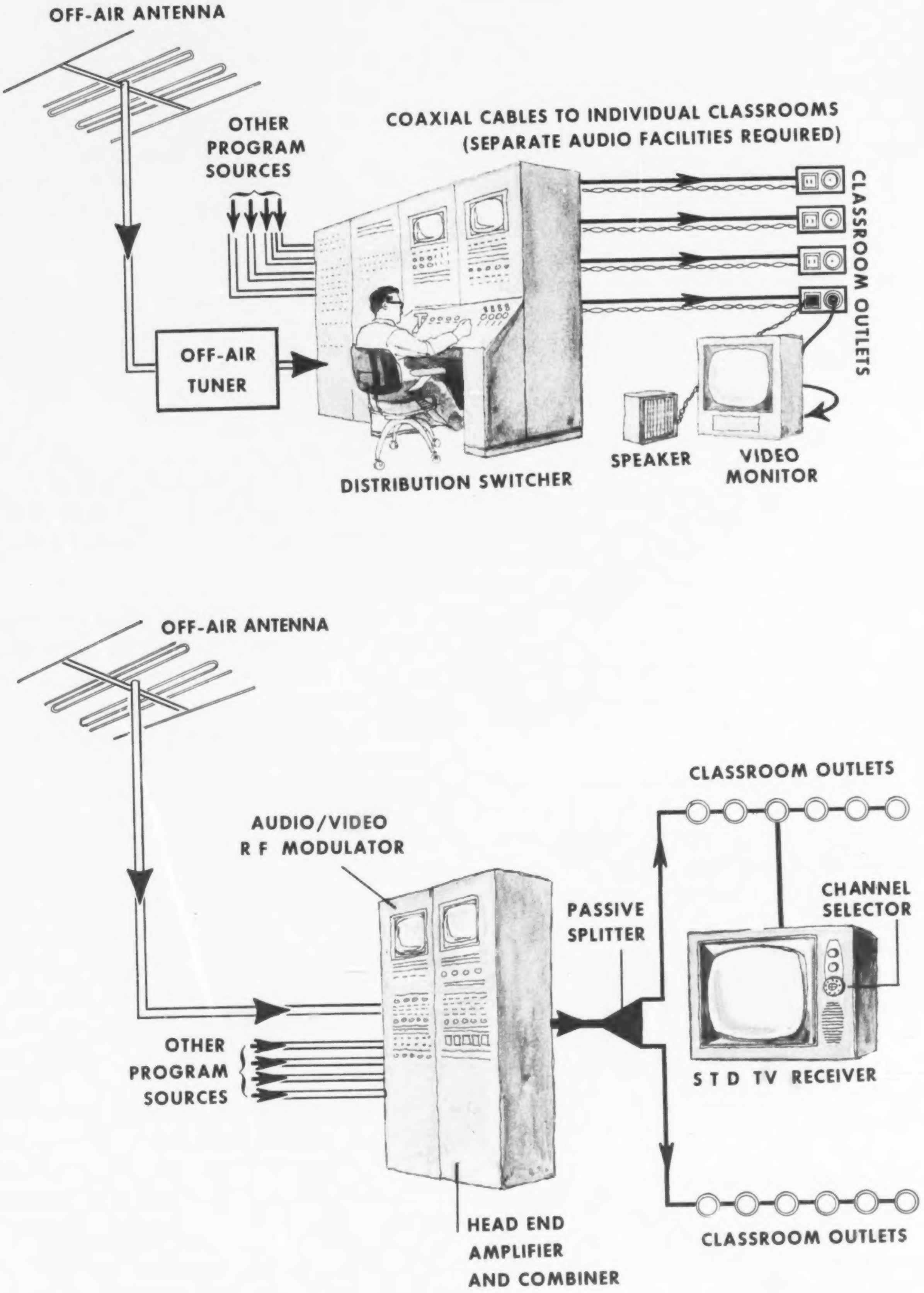
[1] So-called "jeeped" television receivers, sometimes used in place of the more expensive monitors, are not recommended. Inferior performance often results which is not consistent with the quality capability (and the cost) of a direct video distribution system.

Fig. 11. Diagram of typical distribution systems: (upper) single-channel direct audio/video distribution system; (lower) multichannel RF distribution system.


OFF-AIR ANTENNA
OTHER PROGRAM SOURCES
COAXIAL CABLES TO INDIVIDUAL CLASSROOMS (SEPARATE AUDIO FACILITIES REQUIRED)
CLASSROOM OUTLETS
OFF-AIR TUNER
DISTRIBUTION SWITCHER
SPEAKER
VIDEO MONITOR
OFF-AIR ANTENNA
CLASSROOM OUTLETS
AUDIO/VIDEO R F MODULATOR
PASSIVE SPLITTER
CHANNEL SELECTOR
OTHER PROGRAM SOURCES
S T D TV RECEIVER
HEAD END AMPLIFIER AND COMBINER
CLASSROOM OUTLETS

The configuration of RF distribution systems is generally quite different from the direct video designs. The RF cable systems are characterized by spur lines which "loop through" a group of classrooms, using less cable (and thus less money) than direct video systems. These RF systems may be regarded as miniature CATV systems, serving rooms within one building or perhaps serving several buildings in a complex.

"Off-air" programs from receivable TV stations may be applied directly to the distribution system through a head-end amplifier to provide the proper input level to the cable system. Occasionally, a channel converter is used in such applications either to convert a UHF station to a VHF distribution channel, or to shift a station from one VHF channel to another to minimize interference problems.

Although most RF distribution systems are restricted to the 12 VHF channels, a great deal of development is taking place with new head-end equipment and cables, so that economical distribution will be possible eventually on all UHF as well as VHF channels.

The important characteristics of these systems may be summarized as follows:

- RF distribution systems are generally less costly than direct video systems.
- RF systems, when used with their natural "partners," the standard VHF television receivers, do not provide the picture and sound quality that one can expect from direct video systems.
- Like its big brother, the CATV system, the RF distribution system has a multichannel capability and does not require separate audio lines.
- There is no central switching system, thus, teachers may directly select available programs in the classroom.
- RF systems may be designed to permit the distribution of programs that are originated from classrooms within the system.

Modulated RF distribution systems are generally used where the receiving points (such as classrooms) are distributed over a rather large area, such as a major building or between buildings on a campus, and where a degree of picture resolution and sound quality may be sacrificed in the interest of economy.

TELEVISION IMAGE DISPLAY DEVICES

The most familiar television image display device is the home TV set. Television, however, is seen through numerous devices, some of which only vaguely resemble the typical television set.

For this discussion, image display devices have been divided into two categories—direct view equipment and projection equipment. As the names imply, direct view hardware displays the television image directly on a TV screen; your home TV set is a direct view device. Projection equipment receives the image and projects it, rather like an all-electronic movie projector, on an ordinary movie screen. Within these two categories there are some subtypes to be discussed.

Direct view equipment includes video monitors (usually used with the direct video distribution systems already described) and RF monitors/receivers (essentially ordinary TV sets). **Projection equipment** is subdivided into those using a direct light system and those using modulated light. By and large, the former are cheaper and the latter are better.

VIDEO MONITORS.—Direct view video monitors exhibit the three following general characteristics:

1. Single-channel video input without channel selector
2. High horizontal resolution capability (600 to 800 lines)
3. Separate audio system required

Video monitors are normally used in television production studios and with high-resolution single-channel video distribution systems where image detail and audio quality cannot be sacrificed in the interest of economy. Observation of surgery in teaching hospitals is an example. In addition to the video monitors used with the video distribution system, the installation system must also include a separate audio cable paralleling the coaxial video cable system. Direct view video monitors with 21" to 23" screens suitable for classroom use cost about $500.

RF MONITORS/RECEIVERS.—Direct view RF monitors/receivers exhibit the following characteristics:

1. Multiple-channel RF input with channel selector
2. Limited horizontal resolution (250 to 300 lines)
3. Integral audio system

RF monitors/receivers are nothing more than standard television receivers which are always used with RF distribution systems. Such receivers have standard channel dials which may be used to select any standard VHF or UHF signal available from an antenna system or a closed-circuit RF cable distribution system.

Some of the audio systems which are built into standard TV receivers may not be adequate to provide sufficient volume without excessive distortion. This disadvantage and the 200- to 300-line horizontal resolution limitation are the chief factors limiting the use of RF receivers as classroom image display devices. These disadvantages are somewhat offset by their low cost which ranges from $125 to $200 for a 23" screen.

Although RF receivers are, in general, not capable of accepting a direct video-signal input, they can be readily modified in the field to provide this feature. This so-called "jeeping" is not recommended since the quality suffers.

A number of television image display devices, specifically designed for classroom use, are available commercially with video as well as RF inputs and a selector switch to permit operation as either a video monitor or RF receiver. The overall quality of these receivers is better than the average TV receivers marketed for general consumer use, although not considered as good as professional video monitors.

One principal advantage of either the video or RF type direct-view monitors is that the light intensity—or average picture brightness—does not vary significantly with the viewing angle, that is, the angle of viewing with respect to a line perpendicular to the center of the screen. On the other side of the ledger, the maximum practical screen size is 27" measured diagonally. Most RF monitors/receivers intended for classroom use are either the 21" or 23" size rather than the larger 27" size which generally requires more maintenance and more expensive picture tubes.

DIRECT-LIGHT TELEVISION PROJECTION SYSTEMS.—These systems employ a small high-voltage television display tube which develops a relatively small but very bright image which is projected onto a large motion-picture type screen by means of suitable optics.

The most common and inexpensive type of television picture projection system employs what is known as the Schmidt optical system (the spherical mirror and the correcting lens) in combination with a small (5 inch) high-intensity picture tube as shown in figure 12.

A very high-intensity television image appears on the face of the projection tube just as it would on a television set. The Schmidt optical system reverses the direction of the light rays to form the projected image on the screen. The barrel serves to provide mechanical support for the projection tube and lens systems as well as protection against soft X-rays emanating from the front of the projection tube face.

Projectors of this type "throw" an image on a standard motion-picture screen ranging from 6 by 8 to 20 by 15 feet. The screen is normally placed at a distance of from 15 to 35 feet from the projector. Either front or rear screen projection may be used with the appropriate screen.

The brilliancy of the projected image is considerably less than a typical 16 mm. motion picture (particularly for the larger 20 by 15 foot image) since the total light available for projection is limited by the maximum brilliancy of the image on the face of the television projection tube. The problem of low image brightness is usually minimized by locating the screen in a dark area to minimize the effects of the ambient light striking the screen.

Notwithstanding the problem of low picture brilliancy—and sometimes poor picture detail—the Schmidt optical projector provides reasonably good results at a comparatively low cost of about $3,600.

Schmidt optical projection systems are generally used in small auditoriums or large classrooms seating 50 or more when multiple small-screen direct-view monitor/receivers are not de-

Fig. 12. Large screen television projector showing use of the Schmidt optical system.

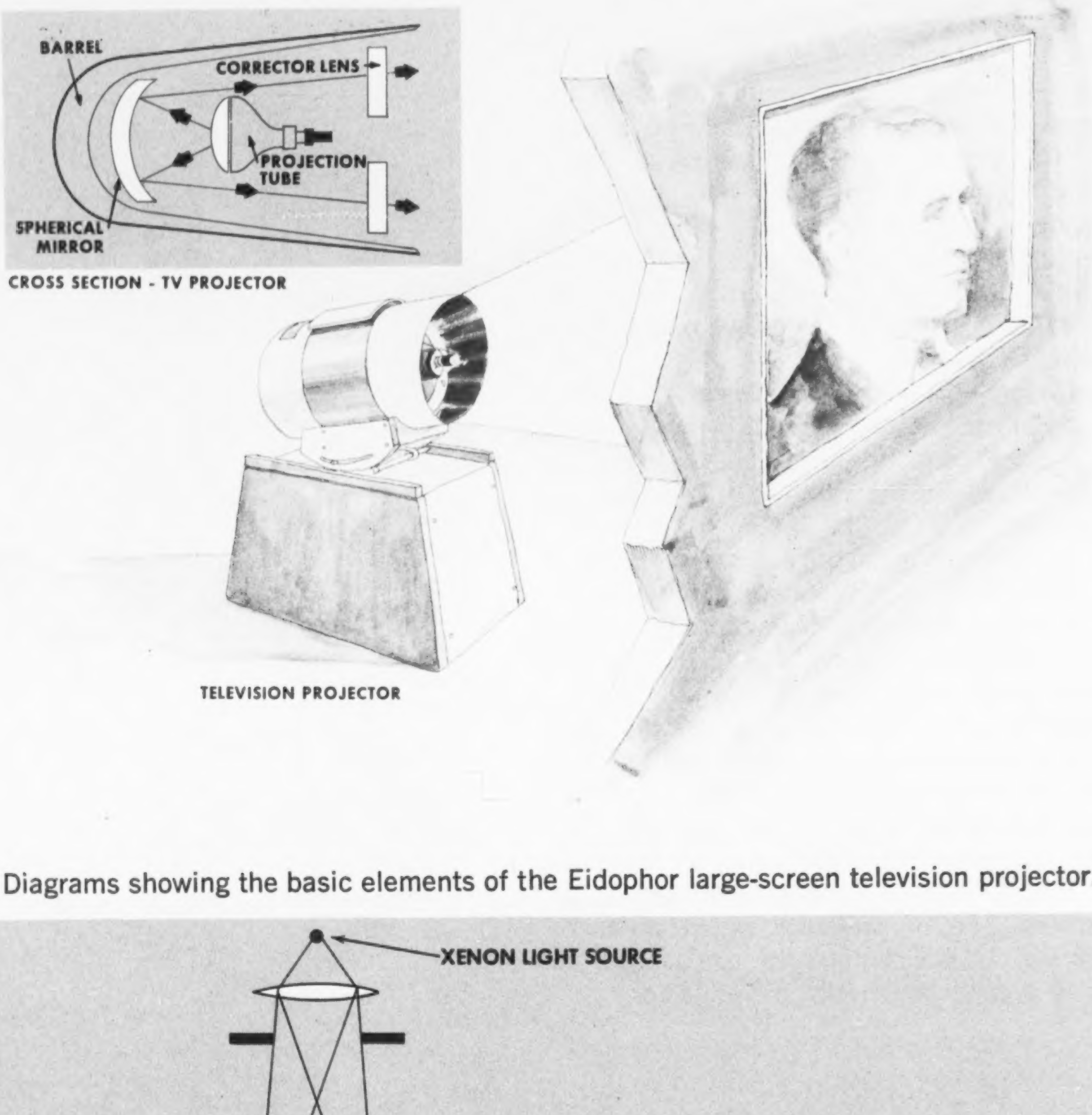
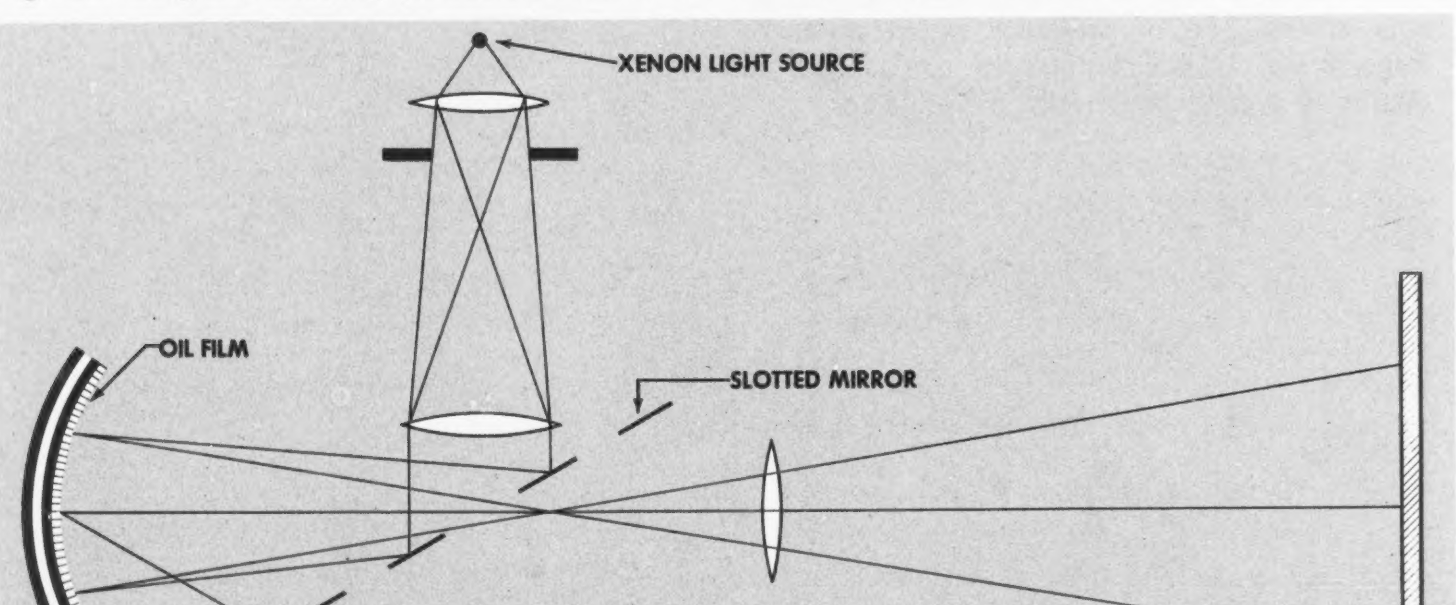

BARREL
CORRECTOR LENS
PROJECTION TUBE
SPHERICAL MIRROR
CROSS SECTION - TV PROJECTOR
TELEVISION PROJECTOR

Fig. 13. Diagrams showing the basic elements of the Eidophor large-screen television projector.


XENON LIGHT SOURCE
OIL FILM
SLOTTED MIRROR
ELECTRON BEAM
CONCAVE MIRROR
VIDEO INPUT
PROJECTION SCREEN
ELECTRON GUN

sirable and where quality in terms of picture brilliancy, picture distortion, and resolution can be sacrificed in favor of a large-screen display.

Almost all of these projectors produce soft X-rays because of the high electron beam accelerating voltages (40 to 50 thousand volts) which are employed. Therefore, if their purchase is contemplated, the degree and effectiveness of X-ray shielding built into the projector housing should be considered carefully.

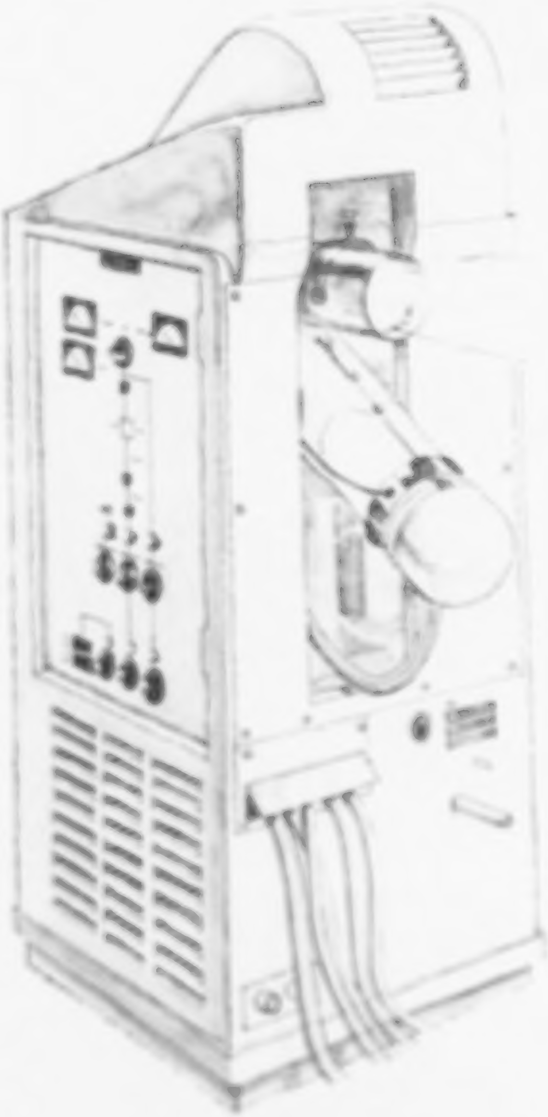
The fundamental elements of an Eidophor projector and how they are related are illustrated in figure 13. A sketch of the projector assembly is shown in figure 14.

The Eidophor is regarded as a television projector which provides by far the brightest television image possible with the least geometric picture distortion. However, the Eidophor is relatively expensive, costing about $50,000.

The General Electric Company in the spring of 1968 announced a modulated-light television projector selling for approximately $35,000, using a "lightvalve" to vary the light intensity under the influence of the video signal.

Modulated-light television projectors are used in large auditoriums where bright pictures with good resolution and low geometric picture distortion are more important than projector cost. This type of television projector may be used for either front- or rear-screen projection and is the only known type of projector which produces large-screen television images comparable in quality to a good motion-picture projector.

Fig. 14. Sketch of the Eidophor projector assembly.



Chapter VII

TELEVISION RECORDERS: THE MARVELOUS HEADACHE

IN AN EVER-INCREASING number of ITV installations, the critical item is the video or television tape recorder. If a practical, flexible video or television recording technique had not been devised, it is likely that all the other TV gadgetry combined would not have had much impact on instructional practice.

RECORDERS IN PRODUCTION AND DISTRIBUTION

The tape recorder is both a production and distribution tool. In most cases, material to be televised is assembled on tape and played back later. The tape recorder thus provides:

- **QUALITY CONTROL**—If the production effort does not succeed, try and try again.
- **MULTIPLE USES**—The completed production effort can be played to different classes at different times, and can be saved for use in subsequent semesters.
- **A MEDIUM OF EXCHANGE**—Programs can be swapped with other centers or placed in distribution through regional or national tape libraries.
- **A TIME MACHINE**—Accommodating individual schedules, the tape recorder permits one to revisit events.
- **A MIRROR**—It enables a teacher to look at his own teaching for self-evaluation; for example, a student of physical education or speech can study his own performance.

The tape recorder is ITV's keystone development, both as a production and a distribution instrument, related to the studio, the transmission system, the school, and the classroom. It may be found in the largest ETV station and in the one-school installation. There are various tape recorders for various jobs, and they come in staggering quality and price ranges. However, the most difficult problems are not really cost or quality but the struggle for compatibility.

Since the use of these machines is so pervasive and since it is only common sense to share high-quality materials, it is virtually essential that tapes can be playable on a neighbor's machine, and vice versa. It is distressing, then, to find that there are more than a dozen small television tape recorders on the market operating on such a jumble of technical standards that generally speaking each machine only "understands" tapes produced on machines of the same brand. This has resulted in innumerable studies and some pressures on manufacturers to provide some uniformity, but these efforts have not been noticeably successful.

VIDEO RECORDING ON MAGNETIC TAPE

Since a videotape recorder was first introduced to the broadcasting industry in 1956, recorders have been produced in many sizes, types, orders of complexity, price ranges, and quality standards.[1]

Magnetic tape recording is the only practical technique available for storing television signals directly in a manner suitable for immediate playback. Thus the videotape recorder accomplishes for television the same function that audiotape recorders accomplish for radio and recordings. The same basic principles of magnetic recording are used in video and audio, but recording video is obviously more difficult and more expensive.

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[1] The term **Videotape** is a trademark of the Ampex Corporation. In a lower-case rendition it has become a generic term along with kleenex and scotch tape.

Although the variety of hardware is great and the price range may seem preposterous at first glance, it is not too difficult for the nonengineer to absorb their fundamental "common denominator" performance characteristics.

Consider the ordinary audiotape recorder. Given the relatively modest range of frequencies used in recording sound, excellent results are possible if one pulls a quarter-inch-wide tape past a stationary magnetic recording head at a speed of 7½ inches per second. The result is a single long recording track laid down along the length of the tape. A really excellent machine can reproduce frequencies of 20,000 Hz by this method.

This relatively simple technique introduces one of the most fundamental electronic recording concepts. This is writing speed, the relative velocity between the recording head and the recording medium. In the audiotape example, the writing speed is 7½ inches per second, the speed at which the tape is pulled past a stationary head. It would make no difference to the process if the recording head moved past the tape. It is just mechanically more sensible to move the tape.

Now consider the writing speed requirements for recording television signals. Where the audio recorder had to handle 20,000 Hz (20 kHz), a video recorder has to have an upper frequency response of about 4 million Hz (4 mHz). This requires a writing speed at least 200 times greater, since 4 mHz is 200 times larger than 20 kHz. Thus the writing requirement for high-quality video is 200 times 7½ inches per second, or 1,500 inches per second.

Imagine trying to move tape past a stationary head at 1,500 ips, or roughly 90 miles per hour. One would need 1,350,000 feet of tape for a 15-minute program, and the problems of tape flutter and stretch would be enormous.

QUADRUPLEX RECORDING

The practical answer turned out to be a method where both tape and head (or heads) move in order to achieve the necessary writing speed with a minimum length of tape moving at manageable speeds. Figure 15 illustrates how the high writing speed was achieved with a slow moving 2-inch wide tape. Note that the task of scanning the tape—or laying down the magnetic tracks—is

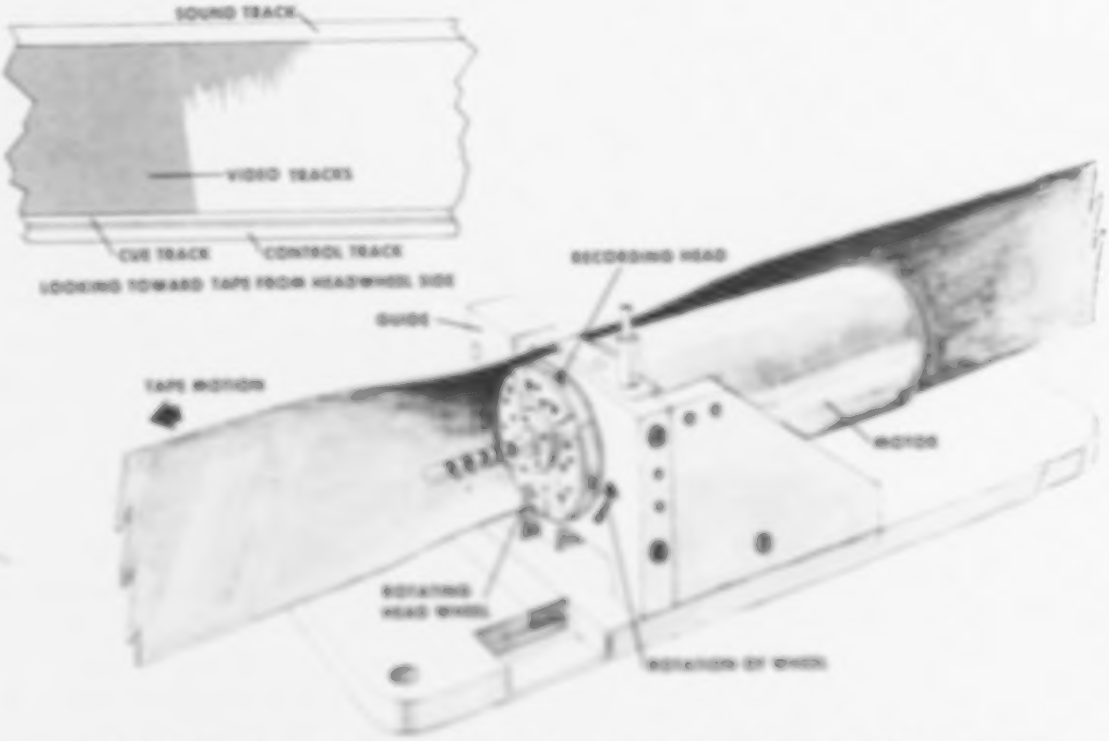

Fig. 15. Videotape recording: (upper) diagram showing principle of tranverse-track scanning; (lower) diagram showing the transverse-trackscanning format.

shared by four heads equally spaced around a high-speed rotating wheel, the circumference of which is four times the tape width. The tape is moved only fast enough to separate the successive magnetic tracks laid down by the rotating heads. The result is a set of magnetic tracks almost perpendicular or transverse to the direction of tape motion as also shown in figure 15.

This method of achieving a high writing speed was named "quadruplex" after the number of heads used. The term "transverse track" could have been used just as well to distinguish the method from the longitudinal track of audio recording.

In addition to the video tracks, it is also necessary to record a conventional longitudinal audio track and a control track, essentially "electronic sprocket holes" to insure that the playback head scans the recorded video tracks precisely.

SLANT-TRACK RECORDING

The new lower cost, relatively lower performance, more-or-less portable videotape recorders use a somewhat different scanning process. These machines lay down relatively long slanted tracks rather than nearly perpendicular transverse tracks (see figure 16). The key to the technique is a rather large scanning drum containing one or two magnetic heads. The tape is wrapped 360 degrees around this drum in helical fashion, as shown in this figure.

Once again, the tape is moved just fast enough to separate the successive slanted tracks, and the head (or heads) rotate on a high-speed disc inside the drum. Virtually all of these machines have chosen a combination of tape width, number of heads, head speed, and tape speed so that the time duration of each slant track is exactly equal to one television field (252.5 horizontal lines). Although this characteristic provides slant-track machines with one unique capability, the process also has some drawbacks, as described below.

A high writing speed, then, may be achieved in various ways. The basic point is that it must be achieved if the machine is to record enough for a high-resolution television picture.

Of equal significance as a performance measure is the video signal-to-noise ratio which provides a given picture-to-snow ratio of the reproduced television image. The video signal-to-noise ratio is established largely by the width of the recorded magnetic track.

In summary, good picture resolution is achieved through high writing speeds; good picture-to-snow ratio is achieved by relatively wide recording track. These facts have some practical implications when one is shopping for recorders.

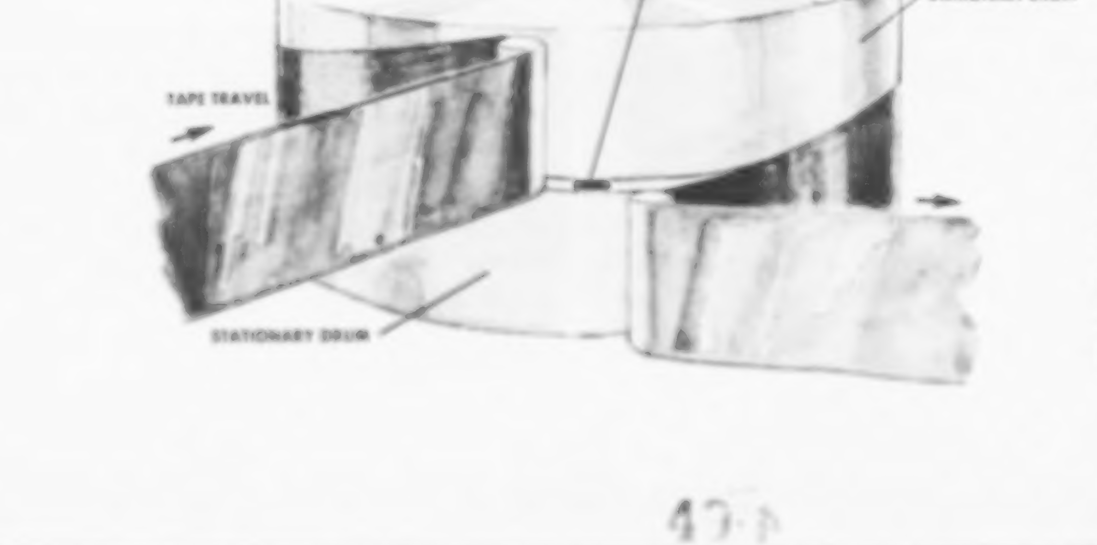

Fig. 16. Videotape recording: (upper) diagram showing principle of helical scanning; (lower) diagram showing the slant-track scanning format.

QUADRUPLEX (TRANSVERSE TRACK) VIDEOTAPE RECORDERS

It is commonly believed that achieving compatibility is difficult in those pesky helical-scan recorders, but quadruplex machines all use the same standards. This is not true since there are two major variations in the quadruplex recorders: (1) high- or low-band modulation standards and (2) narrow- or wide-gap widths in the recording heads and corresponding tape speeds. These facts are given here only to point out that these four-headed "standards of the industry" have variations, explaining why prices for quadruplex machines may range from $25,000 to $110,000.

The following paragraphs summarize the performance levels, features, applications, and costs of the quadruplex recorders available through 1968.

The most versatile, highest quality tape recorder yet produced is the high-band quadruplex machine. These high-band machines were developed specifically for the recording and reproducing of the best possible color television images. As such, these machines are also capable of providing the highest quality black-and-white pictures, with a horizontal resolution of 400 lines[2] and an output video signal-to-noise ratio of 46db.

These machines are used generally in the major production centers and larger TV stations. They are usually equipped with such features as electronic editing facilities, circuits for automatic timing error corrections, compensators for "drop-out" tape flaws, full electro-mechanical devices to optimize all reproduced image characteristics, and most complete monitoring facilities. The total cost of a machine so equipped is approximately $110,000.

Quadruplex machines operating on high-band standards can be purchased for as little as $50,000 by eliminating sophisticated optional equipment.

The machine most commonly used in both commercial and educational TV stations is the low-band quadruplex recorder, which has been on the market much longer than its fancy high-band cousin. These machines can be equipped with all the optional extras and are capable of comparable resolution and video signal-to-noise ratio, but high-quality color performance is still beyond them. The price range is from $35,000 to $50,000, depending on options.

A third class of quadruplex machines has been developed for closed-circuit use so that the vast store of resource materials available on 2-inch transverse-scan tape can be utilized. These machines have been stripped of all nonessentials to achieve a lower cost. Performance can be very good if the operator is experienced and understands videotape control. These machines can be purchased for as little as $25,000.

Any of these machines can be equipped for tape speeds of either 15 inches per second or 7.5 ips. There are, of course, quality tradeoffs to be made, which should be examined briefly.

As pointed out earlier, the picture-to-snow (signal-to-noise) ratio is closely related to the width of the magnetic track. This is why audio recordings of the highest quality are frequently made on the full width of 35 mm. magnetic film rather than on the familiar quarter-inch tape.

When the tape speed is cut from 15 to 7.5 inches per second, one obviously must figure out how to get the same number of transverse video tracks on half the length of tape. This is possible by cutting the width of each track in half, from 10 to 5 mils.[3] As just noted, this will necessarily affect the video signal-to-noise ratio.

Also, while the video writing speed has not been cut (there are still the same number of tracks), the audio writing speed is cut in half, since the audio track is laid along the tape length, just as in conventional audio recording.

The major advantage of the lower tape speed is that the amount of tape one has to buy is cut in half, and viedotape is expensive. For most purposes, the reduction in technical quality is not serious.

There are, however, other technical disadvantages, including a considerable reduction in the life of recording heads, which cost money to refurbish—from $650 to $700 in 1968.

With all these variations, the quadruplex machines are the standard of the industry, and their technical superiority over the helical-scan machines is undisputed.

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[2] There are several techniques for determining lines of resolution. Some manufacturers claim 400 or more lines for machines of lesser quality, but they do so on the basis of rather optimistic procedures.

[3] A mil is a thousandth of an inch.

HELICAL SCAN OR SLANT-TRACK VIDEOTAPE RECORDERS

The recent introduction of a series of low-cost devices, known as helical scan or slant-track videotape recorders, will present many problems to the administrator, some even more confusing than the television camera problems discussed earlier. One of the difficulties he faces is that the situation will have changed—probably for the worse—before this publication is printed. Nevertheless, some basic principles may help him make the right decisions.

The dimensions of the thicket through which the administrator must struggle are noted below. As of 1968, all helical-scan recorders used some combination of the following design parameters:

Tape width (in inches): 2, 1, ½, ⅜

Tape speed (inches per second): 3.7, 4.5, 6.9, 7.5, 9.0, 9.6, 10.0, 12.0

Writing speed (inches per second): 130, 550, 590, 631.5, 650, 723, 833, 930, 1000, 1036

Number of heads: one, two

Video track width (in mils): 5.9, 6.0, 6.2, 7.0, 7.1, 7.5, 8.0, 10.0, 15.0

Even if one ignores the last parameter (video track width), a total of 640 different combinations of standards is possible. The industry was well below that theoretical number at the end of 1968. To the casual observer, however, it appears that the manufacturers are making every effort to close the gap. Should they succeed, there will be 640 ways to record video on slant-track machines, all incompatible with the other 639.

STANDARDIZATION.—Standardization is an absolute requirement for quadruplex VTR machines costing from $30,000 to $110,000. Such machines are generally used not only to achieve maximum quality, but also to play back syndicated network tapes in both commercial and educational television stations. These tapes come from many sources, but the same machine must play them all.

As a matter of fact, this standardization between machines of different manufacture was virtually dictated by the broadcasters as a condition for purchasing. This is an important point for the educator, since it again demonstrates the significant forces which are—in the final analysis—responsible for equipment standardization. Equipment standardization in any field—and television is no exception—is determined largely by what the purchaser demands as a condition for purchasing. Expressed in a different way, equipment standardization is frequently determined largely by which manufacturer has sold the largest number of machines.

Unfortunately, helical-scan recorders are available in so many different standards and tape formats that the educator finds it very difficult—even with competent technical assistance—to make a good decision. This is particularly critical since the educator is aware that merely to purchase a popular machine contributes to the acceptance of that standard—good or bad—while the purchase of a less popular brand operating on another standard serves to further confuse the situation.

COMPATIBILITY OF MACHINES.—If there is a single term which keeps popping up in any helical-scan videotape recorder discussion, it is compatibility. This term does not have the same meaning for everyone. For example, a given machine may be compatible with another of the same make and model, compatible with the same make but different model, or compatible with other machines of different makes and models.

As elementary as this requirement is, during the period when slant-track machines were being introduced it was necessary to play a tape on the same machine on which it was recorded in order to obtain satisfactory results.

As the electrical and mechanical tolerances of the machines tightened, it became possible to play a tape back on any machine of the same make and model as the recording machine. Even quadruplex machines passed through the same phases of compatibility immediately after they were introduced to the broadcast industry in 1956.

The next order of compatibility involves the ability to reproduce a videotape made on a standard slant-track recorder on **any** other standard slant-track machines of other manufacturers. As of December 1968, no two manufacturers of slant-track machines used the same recording standards and tape format. Some manufacturers even had several models not compatible with each other.

However, at least one manufacturer has marketed a series of five slant-track machines which makes use of the same standards and tape width so that a recording made on any one of the series may be reproduced on any other model in the series. These machines range in price from the lowest cost $995 model to the "top-of-the-line" model which is suitable for monochrome broadcast use and sells for $12,500.

BROADCAST QUALITY.—The term "suitable for monochrome broadcast use" implies that the video-signal output meets all applicable EIA and FCC broadcast standards. The key word here is "applicable." One should not generalize too much and assume that a slant-track tape recorder meeting "broadcast standards" (frequently referred to loosely as "broadcast quality") exhibits performance as good as its more sophisticated quadruplex brothers. This term "broadcast quality" means only that the picture synchronizing signal delivered by the machine exhibits the required characteristics to insure a stable picture when received on a standard TV receiver.

The term "broadcast quality" provides virtually no assurance that the recorded video signals will be reproduced with the resolution or picture-to-snow ratio that are usual with quadruplex machines. Briefly, when applied to slant-track tape recorders, the phrase "broadcast quality" or "meeting FCC standards" usually refers to the synchronizing pulses and not the picture portion of the composite video signal.

THE PURCHASE COMPROMISE.–The relatively new slant-track machines are currently undergoing a critical development which should result in marked advances. Tempting as standardization may seem, however, it may not be—at this time—the most desirable step in that it could arrest the rapid technical developments.

Since the situation is so fluid, any detailed tabulation of the features and costs of currently available types would probably have little value. However, two basic purchasing principles would consist of—

1. Identifying the significant characteristics of the currently available recorders and establishing a relationship between these characteristics and the selling price.
2. Providing some specific suggestions and guidelines for making a choice between currently available slant-track VTR machines as well as new machines which are virtually certain to be marketed.

Of the many slant-track videotape recorder characteristics, horizontal resolution, expressed in TV lines, video signal-to-noise (picture-to-snow) ratio, synchronization stability, and initial and operating costs are among the most important to the educator.

Horizontal resolution is a measure of the detail present in the reproduced image. Resolution is established by design parameters which have been discussed in previous chapters.

The video signal-to-noise ratio is a measure of the picture-to-snow ratio of the reproduced image. This important characteristic is established by such technical parameters as the width of the video magnetic track on the tape.

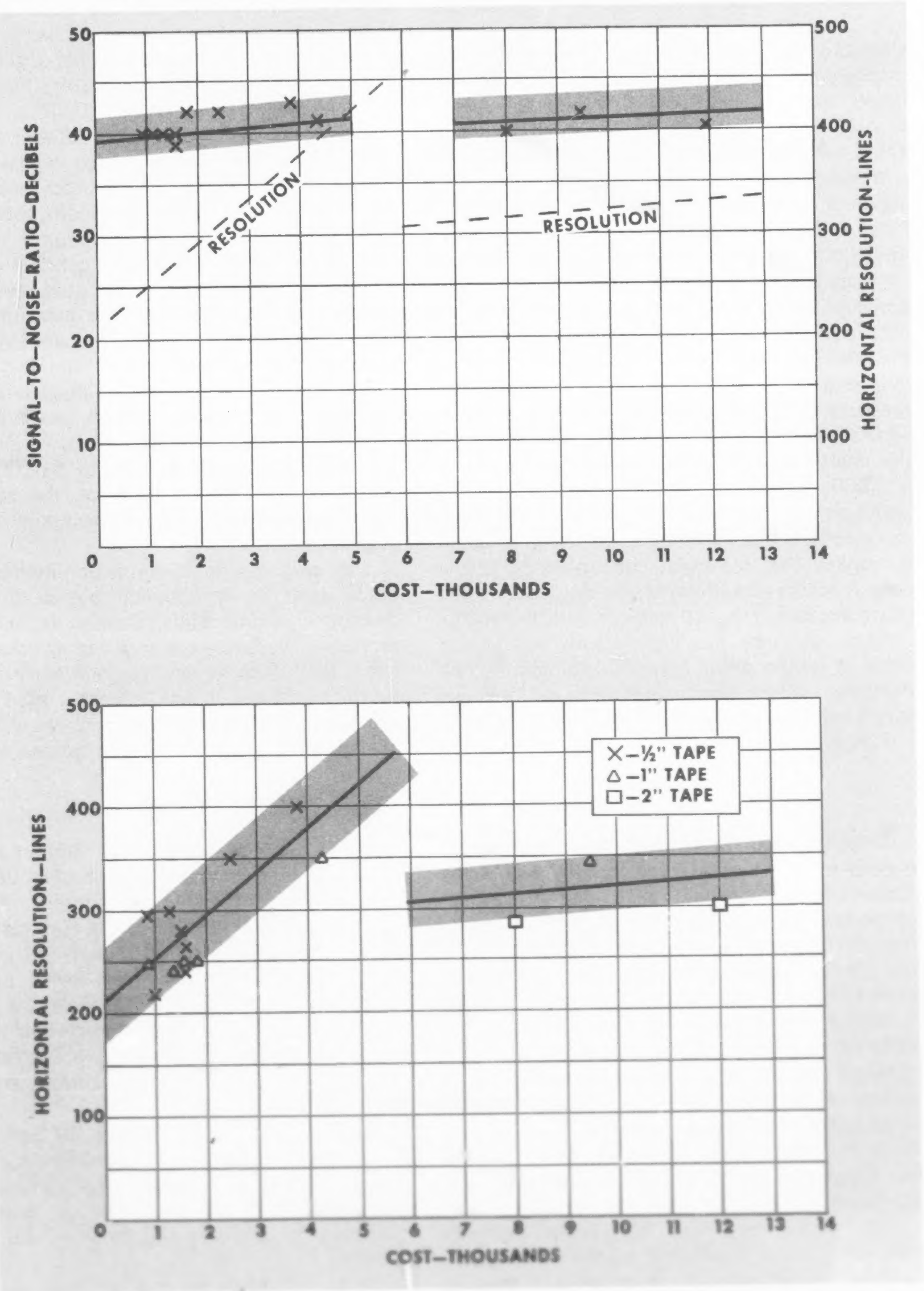
The characteristics of the synchronizing pulses accompanying the reproduced video signal are particularly important when used with a broadcast operation. This is one of the most difficult parameters to pin down since it is determined partly by the electronic design and partly by the mechanical precision of the machine itself. Manufacturers do not generally quote specifications for this characteristic since few slant-track machines are recommended for broadcast use. Furthermore, the machines that are recommended are equipped with a synchronizing pulse processor, usually referred to as a "processing amplifier," to bring the shape of the pulses into compliance with FCC requirements. At the end of 1968, there was no slant-track VTR machine suitable for broadcast use unless it was equipped with either an internal or external processing amplifier.

SLANT-TRACK RECORDERS AND THE VALUE/COST RATIO

The initial cost of instructional television equipment alone is not as important as the value received for the money spent. With this in mind, the important measurable characteristics of interest to the educator—that is, horizontal resolution and video signal-to-noise ratio—have been plotted against cost in an effort to establish a relationship between value received and cost.

The horizontal resolution in TV lines in relation to cost for 14 slant-track machines available in the spring of 1968 is illustrated in figure 17. The straight solid lines represent the best average fit

Fig. 17. Horizontal resolution and video signal-to-noise ratio in relation to recorder cost.



to the measured quantities provided by the manufacturers. Evidence of a marked trend or relationship is clearly evident even though there is considerable variation in different manufacturers' measurement methods. An examination of this figure suggests that the resolution is roughly proportional to cost only for the lower cost machine, those in the $995 to the $4,135 range. The correlation between resolution and cost is less apparent in machines of the $8,000 to $12,000 range, although this may be due to the availability of fewer examples in this cost bracket.

If any conclusion can be drawn from the relationship shown in this figure, it would seem that resolution is roughly proportional to cost in the price range from $995 to $4,135 and roughly independent of cost in the $8,000 to $12,000 range. Is the $12,000 machine no better than the $8,000 machine? It happens that the points on the chart corresponding to the $8,000 and the $12,000 machines are for recorders of the same brand and general type except that the $12,000 machine is equipped for color operation. It could be argued that the point corresponding to the color machine should have been omitted from the chart because it is out of place with the monochrome machines. This merely demonstrates that often it is the extra features available with a machine rather than improved performance which increase the cost.

Figure 17 shows the video signal-to-noise ratio in relation to the cost for the same machines. At first glance the results seem to indicate that the video signal-to-noise ratio is substantially independent of cost. Is it really possible to get as good a picture-to-snow ratio with a $995 machine as with one selling for almost $12,000?

How can one explain the difference? Engineers know that the measured signal-to-noise ratio of a picture may be increased considerably by reducing the video bandwidth, but if the video bandwidth is cut the resolution is impaired. Superimposing the resolution cost data onto the signal-to-noise findings in this figure reveals that this is true here. Although the measured video signal-to-noise ratio has been maintained with the lower cost machines, the resolution—the picture detail in the reproduced image—has been reduced. Furthermore, neither resolution nor signal-to-noise ratio appear to vary significantly for recorders in the $8,000 to $12,000 price range. At least in this instance, the additional $4,000 bought color and not resolution or video signal-to-noise ratio.

The foregoing illustration is not intended to be either definitive or complete, but an attempt to develop a cost-benefit evaluation technique for evaluating performance received against money spent that could be applied to either present or future machines. It also indicates a method of separating technical performance characteristics of slant-track recorders from the optional features.

PURCHASING GUIDELINES FOR SLANT-TRACK RECORDERS

Although the market appears to be glutted with a great variety of slant-track machines, in some cases it is only the name plate and not the machine that is different. This is because some manufacturers of a broad line of electronic equipment offer, under their own brand name, machines that are manufactured by others. Hence, it should not be concluded that, just because a recorder carries a different brand name, it is different from all other machines. Obviously, such machines are fully compatible with machines offered under the prime manufacturer's own name. Once the prime manufacturer is identified, one can happily conclude that perhaps some degree of compatibility exists between machines.

The "slow motion" and "stop frame" features offered by some slant-track machines are probably somewhat oversold. Such features may be valuable for the analysis of certain sporting events such as football and have been used successfully for precisely that purpose. Although good educational uses for these features can be found, the educational innovator should recognize that, with the recording format presently employed with slant-track machines, the vertical resolution of the displayed "slow-motion" or "stop frame" picture is exactly one-half the resolution obtained in the machine's normal mode of operation.

Furthermore, merely stopping the tape seldom produces a satisfactory picture without a "noise band" or "tearing" tendency in the picture's upper part unless the tape position is adjusted manually to obtain a satisfactory "still frame" picture.

Some comments on the two-head vs. single-head slant-track machines may be helpful. One redeeming feature of the slant-track machine is the elimination of the electronic and mechanical complexities necessary with the four recording playback heads of quadruplex machines. Thus if these problems can be eliminated in "low budget" machines, it is reasonable to go to the irreducible minimum of one head.

One major advantage of the single-head configuration is the lower replacement cost of heads and the fact that anyone can replace the head of some machines in a few seconds. The reason for this easy replacement lies in the fact that the two-head machines require that the heads be precisely aligned so that they record exactly parallel tracks on the tape. Obviously, this exacting adjustment is unnecessary on a single-head machine.

Some slant-track machines are offered with two output channels. In addition to the usual direct video output, an RF channel allows the user to display the recorded program on an unused channel of an ordinary TV set. Although this is a desirable feature, there are at least two limitations which should be noted. First, the RF output of some machines carries the picture information only, without the associated audio portion of the program. This means that a separate audio cable and speaker must be provided for playback of the sound. Second, the nature of the RF output signal is usually such that it may cause interference in a multichannel television system.

One of the most difficult problems in evaluating slant-track machines is how to assess construction quality and mechanical ruggedness. One might devise some simple tests, but it is clearly impractical for the prospective purchaser to obtain samples of several machines and drop them all from the same height to determine which machine disintegrates into the fewest pieces. At least a more reasonable alternative is to note the tape deck thickness supporting the head drum and the takeup and feed-reel spindles. Machines produced by the more quality-conscious manufacturers will generally use a heavier casting or a thick aluminum plate. The tape deck construction may well be an indicator of the quality of other less obvious but equally important components inside the machine.

Assuming that you have decided to purchase one or more slant-track VTR machines, what procedures can be followed to help make the best decision? Some suggested guidelines are given below:

1. Make a list of the features you most desire for your machine, such as color capability, suitability for broadcast use, remote control capability (required for use in remote access retrieval systems), slow motion and stop-frame features, and electronic editing capability. This step alone will eliminate a number of contenders.

2. Tabulate and plot vs. cost the resolution and video signal-to-noise ratio characteristics of all slant-track machines available at the time of the proposed purchase. This is where professional engineering assistance will be most valuable.

3. Try to weigh the following from the conclusion reached from the above:

    a. The tape format used on available syndicated educational resource material which you may want to use.

    b. The per hour cost of videotape required for the machine.

    c. Terms and conditions of the head guarantee, and the cost of replacement heads.

    d. The ease of replacing the head assembly—must the head drum or the entire machine be sent to a service station for head replacement or can it be replaced on site?

    e. The availability of replacement parts without long delay and the availability of service information.

    f. The accessibility of a maintenance training school operated by the manufacturer which your service technician may attend.

4. Following the tentative selection of a machine, obtain a list of users from the vendor in order to obtain first-hand information of the performance and reliability of the selected machine.

If the machine you have selected has the features you want at a price you want to pay and if it passes the test in step 4 above, you have a reasonably good chance of getting your money's worth.

DUBBING (Re-recording)

Once your slant-track tape machine has been delivered, installed, and placed in operation, the need soon arises to make a copy of a program that you have recorded. You are now in the "dubbing" business. Your original tape becomes the **master,** and your task is to provide **dubs** with a minimum loss of sound and picture quality. Be reconciled to the fact that there will be a loss in quality—tapes cannot be improved by the dubbing process.

The high quality quadruplex broadcast recorders can make dubs that are almost indistinguishable from the master tape. With lower quality machines, however, the chances of obtaining a successful dub are directly proportional to the quality of the machine. Eventually a point is reached, with some of the low-cost, low-quality machines, where it may be impossible to obtain a recognizable picture when the dubbed tape is played back. If your equipment includes only one recorder, or if your operating schedule does not permit the time required for dubbing, then you must rely on outside agences for dubbing services. Dubbing centers are operated by some manufacturers of slant-track recorders, and the quality of dubs produced by these centers will usually equal or surpass the quality you are capable of producing with your own equipment. Dubbing service is also available from some local equipment distributors or from large closed-circuit installations which provide this service to outside organizations. Dub quality available from these sources is variable, depending on the quality of their equipment and the skill of their operators. However, if an agency in your locality can provide good quality dubs, it is often more convenient to utilize this service than to send your masters to a manufacturer's dubbing center in a distant city.

Dubbing centers can provide some other services which you may not be able to duplicate. Many centers can furnish dubs from one tape standard to another, thus providing a solution to the incompatibility problem. This is especially valuable if you wish to obtain a slant-track dub from a quadruplex tape originally recorded for broadcast. Film-to-tape transfers are also available, and are useful if you lack a film chain in your system.

If you need multiple tape copies made with your own equipment, the most satisfactory results will be obtained by recording on two or more machines simultaneously when the program is originally recorded. This results in multiple masters and avoids the loss of quality inherent in the dubbing. If the multiple master technique is not feasible, then dubs may be made by connecting one recorder's output (the playback machine) to the input of another (the record machine). This connection may be made by patch cables or through your audio and video switching system.

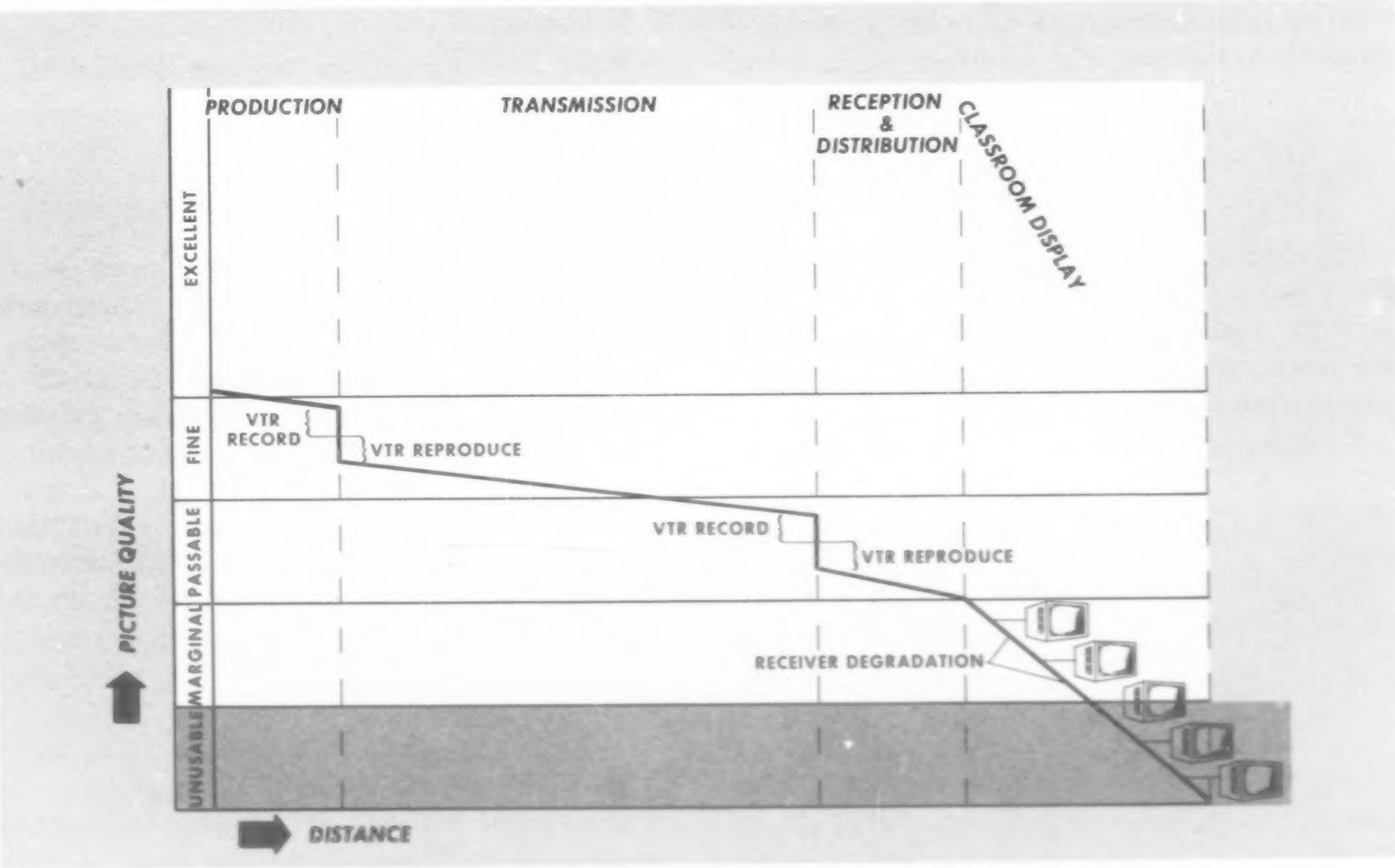
If your plans call for extensive dubbing to provide copies of tapes for distribution, then the purchase of a stabilizing or processing amplifier should be considered. This amplifier is interposed between the playback and record machines in the dubbing process and serves to improve the dub quality by correcting the synchronizing pulse defects, thus minimizing the possibility of rolling and tearing the reproduced picture. The more elaborate processing amplifiers will further improve quality by minimizing the picture disturbance caused by the "dropout area" which occurs at the top or bottom of the picture as the result of the tape head not being in contact with the tape for a short period each frame. The stabilizing or processing amplifiers cannot, however, correct picture impairments such as poor resolution or poor signal-to-noise ratio. These impairments can only go from bad to worse in the dubbing process.

Occasionally you may wish to make a dub of a tape which itself has been dubbed from a master tape—that is, a "dub of a dub." The resulting copy is referred to as a second generation dub or, if the process is carried further, a third or fourth generation dub. As indicated in figure 18, multiple generation dubs are satisfactory only when made on the highest quality quadruplex broadcast recorders. Attempts to go beyond second generation dubs using slant-track recorders are usually disastrous.

There have been instances where an attempt has been made to improve the quality of slant-track recordings by dubbing from a slant-track machine to a quadruplex broadcast recorder. Since quality loss in dubbing is inevitable, however, no improvement can be obtained. Dubbing to a quadruplex broadcast machine does not result in a broadcast quality tape that meets the FCC standards for on-air transmission. The quadruplex machine will only accentuate the defects of the original slant-track tape, and the dub will usually appear worse than a dub made with two slant-track machines.

Satisfactory dubbing of slant-track tapes demands better performance from the machines than is necessary for the recording. It is especially important that the adjustment of certain internal controls in the machines be identical for both the playback and record machines. Machines used for dubbing will therefore require more careful and more frequent maintenance. Greater skill is required of the operators, and they should be thoroughly instructed in the dubbing techniques. Such instruction is available in seminars conducted by some manufacturers at their plants, or can often be obtained from manufacturers' representatives who will instruct your staff in your own studios.

Fig. 18. Picture quality resulting from multiple generation dubbing. (The more you dub the poorer the picture becomes.)



THE TELEVISION TAPE LIBRARY

The television tape library is a major byproduct of ITV and the television recorder. As one would expect, these libraries range all the way from the well-known centers, such as the National Great Plains Instructional Television Library and the National Instructional Television Center, to a few tapes in a box at the local school.

There is a tendency to equate television tape libraries with film libraries. The two are not much alike, however, and their differences can be traced to the transitory nature of videotape and television. Two fundamental differences between television and film are that television production generally consumes far less time, and tape stock can be reused. Thus, an ITV production is hardly ever considered finished, cast in bronze for the ages. Television teachers and producers commonly retain professional rights over the product, so that it can be withdrawn or reproduced when it is out of date or when improvements become feasible.

On the local level, this characteristic is reinforced by the fact that tape stock represents a higher initial investment than film stock, and so there is a constant economic pressure to weed out little-used material and reuse the tape for better programs.

By and large, films are acquired and, while they can be used only in certain ways, the prints are largely the buyer's property. Not so with instructional television tapes. Reflecting the transitory nature of television, the professional interests involved, and the economics of tape stock, ITV program tapes are generally leased for specific uses during short periods.

All of these factors raise again the problems of compatibility among tape recorders. Suppose the educators in your area consider it desirable to set up an exchange mechanism for locally produced ITV tapes. In how many electronic versions must each program be available? Nationally, the problem is merely a headache. Between two colleges or two school districts, electronic incompatibility may scuttle an otherwise good idea.

In summary, tapes may be acquired for a local ITV library by—

- Local production
- Distribution by national or regional centers
- Making copies (dubbing) of others' production
- Taping programs as they are received off the air

OFF-AIR RECORDING

The recording and reproduction process introduces two successive steps, each resulting in a separate picture-and-sound degradation. When one is recording off the air, the signal as received may be none too good.

If recording off the air is required, however, step one is to assure insofar as possible a ghost-free signal of adequate strength available at the receiver.

Second, a professional-type, rather than standard, off-air receiver should be used. Such a receiver should provide audio and video signal outputs at the proper levels and at impedances that are compatible with the recorder's needs.

Never—and there are no known exceptions—try to make an off-air recording simply by pointing a camera at the TV screen and a microphone at the speaker. The results are a technical disaster.

Last, use the best possible quality videotape recorder to minimize the accumulated degradations in the final product as it appears on the classroom receiver.

A CAUTION ABOUT COPYRIGHT

In this discussion of ITV tapes and their various sources, the matter of copyright should be raised. It is possible to borrow or even buy tape-recorded materials and then not be able to use them freely because of copyright restrictions. In this sense, taped materials are similar to books or films.

However, additional problems arise when you make copies of existing broadcasts. Still further complications result when you start producing materials in front of your own cameras. These complications include the professional rights of teachers, the teachers' interest in subsequent uses of the program, and copyright clearances for visual material which might be desired.

The United States is in a major transitional phase in the evolution of its copyright law. Particularly with the advent of new communications technology, educators and copyright holders are carefully testing their respective positions. It is only prudent to stay abreast of the advice of professional associations, and to turn to local legal counsel when in doubt. Some interesting test cases may be anticipated during the next few years. However, it is better to become involved in that sort of thing on purpose rather than by accident or neglect.

Chapter VIII

WHAT ABOUT COLOR?

VIRTUALLY NO CONSIDERATION of television facilities for educational use can be considered complete without some discussion of color equipment. The degree of interest in the capability to originate or distribute educational programs in color will depend largely on the type of operation. That is, a small closed-circuit operation struggling to appropriate funds for something a little better than equipment intended for an industrial surveillance TV system will wisely defer color consideration to a later stage of development. On the other hand, the large educational or public broadcaster is almost forced into color operations if only to avoid the image of second-class citizenship beside his commercial TV brothers. In any event, at one time or another the use of color must be considered by the educational facilities planner.

COLOR CAPABLE AND COLOR COMPATIBLE EQUIPMENT

All color equipment may be classified into two categories—**color capable** and **color compatible.** Standard color signals are compatible with standard black and white signals. Simply stated, this means that color signals will produce a satisfactory black and white picture on existing black and white sets. Thus it would be expected—and this was certainly the objective of the planners who established the operating standards [1]—that compatible color signals could be handled by any good black and white transmission system. This technical fact, however, soon revealed that the satisfactory transmission of color signals imposed some special requirements. Consequently, it soon became obvious that many elements or building blocks of a complete black and white transmission system would have to be improved or upgraded if they were to be used eventually for the transmission of color signals. Such elements may thus be referred to as "color compatible" to distinguish them from "color capable" equipment, which is directly involved in the **origination** or **display,** rather than **handling** or **transmission** of compatible color signals.

Examples of "color compatible" equipment are:

- High-quality coaxial cables
- Video distribution amplifiers
- Video switchers

Examples of "color capable" equipment are:

- Live color cameras
- Pickup cameras in TV color film projection systems
- Color television sets or monitors

The major purpose of the foregoing discussion is to emphasize that as much black and white television equipment as possible should be color compatible, so that when you "go color" relatively little equipment will become obsolete.

THE PHASING-IN OF COLOR

Some major ITV installations have started their initial designs with color. Most budgets still preclude that decision, however, and planners typically are interested in a reasonable "phasing-in" process. Good color equipment is expensive. "Color compatible" equipment costs little more than equipment capable of handling only black and white signals, whereas "color capable" equipment such as live cameras, film chains, videotape recorders, and monitors/receivers costs approximately three times more than black and white. To make economic matters worse, the factor of three must be applied to major equipment items costing thousands rather than hundreds of dollars.

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[1] The operating standards for modern color television systems were established in the early 50's by a joint industry technical committee known as the National Television Standards Committee (NTSC).

Assuming that you are planning to start with a good black and white system and gradually phase-in color equipment as needed, the following specific steps may be followed:

1. Purchase only color compatible passive transmission equipment (i.e., cables) and active signal handling/processing equipment (i.e., switchers).

2. "Color-proof" the transmitter for a VHF or UHF broadcasting station. This will usually involve some relatively minor terminal equipment at the transmitter plus a technical showing to the FCC that color signals can be transmitted without excessive distortion. If a 2,500 mHz system is involved, some minor terminal equipment will also be necessary to meet the FCC requirements. Thus with "color-proofed" transmitters, you can accept network feeds or rebroadcast "off-air" color programs.

3. Next, provide the simplest color origination facility. This may involve adding the necessary color modules to an existing video tape reproducer or adding a color film chain. The choice will depend largely on the type of black and white video tape recorder and the availability of color tapes for playback in the tape format (tape size and recording standards) employed in your shop. The addition of a color film chain may be considered an excellent starting point for the following reasons:

- Color film chains are usually less expensive than live color cameras.
- A wide range of color resource materials are available in 16 mm. color motion picture films and 2" x 2" slides.
- Color materials can be produced with an ordinary 16 mm. movie camera and 35 mm. still camera with a playback delay no greater than the film-processing time.

4. Colorize or purchase a color video tape recorder/reproducer—if this was not done in step 3 above.

5. Finally, acquire studio color cameras along with the appropriate lighting facilities to permit the production of live color programs for immediate use or tape recorded for later use.

The steps outlined above should provide a relatively painless entry into color television without making black and white equipment obsolete, and prevent overloading your facility at one time with expensive color equipment which might soon become outmoded by rapid changes and improvements.

Chapter IX

YOUR ITV STAFF

WHETHER THE ITV STAFF consists of one man or a hundred, the jobs to be performed can be roughly divided under administration, production, utilization, and technical categories. Somebody has to set goals, allocate resources, and mind the store (administration); work with teachers to plan the development and application of materials (utilization); prepare materials for use (production); and operate and maintain the equipment (technical).

Although the same general categories describe audiovisual staff tasks of past decades, television has brought about important differences, some of which are mentioned here.

1. Television staffs tend to be much more concerned with the production function, not merely as a personal preference but because of television's transitory nature. Television programs, produced on a reusable tape, usually have a relatively short, useful life. Even within that period, individual programs or segments may be reshot several times. A television series commonly undergoes a continuous updating and evolution throughout its lifespan.

2. A well-designed television series is usually much more integral to the curriculum than is a given film or set of slides. A teacher selects a film as backup to illustrate his work, but he conducts a kind of continuous interaction with a good television series. This fact has serious implications for television operation design and ultimately for the whole educational strategy.

3. Although electronic equipment is becoming more reliable and stable, specialized maintenance is always necessary. In even a modest size installation, it is a good investment to have a man available at all times for preventive maintenance and trouble shooting. Perhaps it should be noted that, although film projectors may function excellently, reasonably well, or not at all, a television system seldom fails to turn out some kind of a picture. This fact is more often a fault than a virtue, because a bad picture can create a bad learning experience and hence an unsatisfactory teaching experience. Furthermore, gradual quality degradation is insidious, often occurring so gradually that it may go unnoticed and unrepaired. Electronic equipment cannot be kept in shape simply by changing a lamp, blowing out the dust, or oiling the motor.

STAFF QUALIFICATIONS

A television operation places in close working relationship two groups: the first may be called "content personnel" for they are responsible for the administration, utilization, and production of the ITV program; the second, the technical group that operates and maintains the equipment. It is generally true that these groups have different backgrounds, different training, different professional interests, and, quite often, different temperaments.

Although stereotypes are always dangerous, content personnel are usually thought of as rather intuitive in approach, imaginative, creative, perhaps inclined to be extroverted. Technical personnel, on the other hand, are seen as deductive, methodical, and relatively introverted. The intergroup relationships are, in a word, not uniformly harmonious.

It is important, then, to select with particular care those key people in each group who will be working together regularly across that vague line that divides content and engineering. And it is equally important to invest the administrative time and skill to imbue all hands with the knowledge that each man is vital to the same goal: the instruction of students.

The real pivotal position in this effort is probably that of the top engineer. He may be called the director of engineering, the chief engineer, or, in a small installation, **the** engineer. Look for diverse attributes in addition to engineering competence when you hire your top engineer.[1] He needs to be a master of the hardware and a good leader of other technicians. Hopefully, he understands production problems and exhibits general administrative ability.

But look for other clues. If you find a man who meets sound technical criteria and also proves to be a serious amateur photographer—or better still, an actor in the local theater group—hire him before he gets away. Chances are that he will help amalgamate the entire staff into a harmoniously functioning single-purpose group.

In studying ITV staff qualifications, one might consider separately those functions related to content and those related to equipment.

CONTENT PERSONNEL.—The qualifications for specific jobs of administration, production, and utilization will vary depending on the size of the staff. But this staff must have certain basic qualifications, and it is dangerous to ignore any of them. Only three are described below.

1. **The ability to function effectively and easily in the educational community.** These people must work well with other professionals actively involved in curriculum matters. By the very nature of things, these new staff members are apostles of change; personal and professional relationships are critical.

2. **A sound knowledge of the medium, its capabilities, and its techniques.** This is a common deficiency, particularly in small or middle-sized installations where ITV personnel are all too often those who were available, probably already on the payroll, and willing to take a whack at it. (Fortunately school districts do not use these criteria when hiring bus drivers.)

   It is quite true that the properly qualified person for the job is all too scarce, particularly at the salaries that many administrators can afford. Still, many ITV facilities are not serving their areas well, simply because otherwise desirable people do not have the necessary training and experience. Such training is available, however, since many colleges and universities offer everything in this field from short institutes to graduate study. If it is necessary to begin ITV operations without a fully experienced staff, early training is urgently recommended.

3. **A thorough understanding of trends in educational technology.** The individual whose horizons are bounded only by the television studio can do a great disservice. Educational practice is moving too rapidly to have any major staff member locked to one approach. The right ITV staff can be immensely helpful by keeping abreast of technological developments in related fields. If they are skillful and adroit enough, they can become an interesting and valuable avant-garde element in the curriculum group.

TECHNICAL PERSONNEL.—In considering technician qualifications, one should put aside some common misconceptions. First and foremost, an FCC operator's license does not make an engineer. The first, second, or third class "ticket" is exactly what is says at the top: an **operator's** license which authorizes the holder to manipulate the controls and adjustments of transmitting equipment. As thousands of license-holding disc jockeys would agree, it is quite possible to study furiously, pass the test, and work as a licensed operator for years without having more than the faintest notion how the hardware really works. There are several positions that require licensed operators—those who operate transmitting equipment regulated by the FCC. But there are many positions for which licensed operators are not required. Some of the largest commercial and educational stations in the country employ directors of engineering who do not hold current FCC licenses, since they do not operate the equipment, working only with other people and engineering ideas. A licensed man is likewise not required in closed-circuit systems, since the FCC does not regulate such systems.

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[1] This principle is useful even in one-engineer shops. These shops grow. Today he's a youngster with a soldering iron. But he's the senior man, and tomorrow he may be behind a desk as director of engineering.

It is certainly not the purpose here to demean the licenses or the people who hold them. But some administrators assume that the license is an FCC endorsement of engineering skill, and there is not necessarily any correlation.

Within a technical staff, there is a range of necessary skills. One tends to think of the men who work behind the camera (or sometimes inside it) as "the engineers." It is likely that only one—the technical anchor man, or chief engineer—can properly be called an engineer. The others are maintenance technicians or equipment operators.

From the standpoint of acquired skills, the operators can be trained most readily and generally command the lowest pay. Their duties consist of operating studio cameras, control room equipment, and such ancillary gear as tape recorders and film chains.

The maintenance technicians have a good working knowledge of practical electronics. This information is not acquired quickly, and it is coupled with skill in using sophisticated electronic test equipment. These men conduct preventive maintenance routines, troubleshoot breakdowns, make repairs, install equipment, and generally hold the place together. As expected, maintenance technicians generally draw higher salaries than equipment operators.

Perhaps the most helpful way to conclude this section is to emphasize two important points:

1. Plan—even scheme—at the outset for an effective maintenance facility complete with an adequate supply of spare parts. Try not to scrimp on test equipment. It will save time and money in moments of stress.

2. Realistic salaries for maintenance technicians may be higher than expected. The demand is great and the supply is short—a situation likely to prevail for some time. One may have to pay a little more than the local market price to attract competent personnel. But if the equipment does not work, it matters not that everything else is perfect.

THE GREAT TALENT SEARCH

Administrators who have assembled an ITV staff will probably agree that the three aforementioned basic qualifications for nontechnical ITV staff members are valid to the point of being self-evident, that the combination is difficult to find, and that finding qualified staff is one of the major problems in developing an instructional television system.

Although these qualifications or criteria are listed in rank order, they are almost equally important. Consider the first two: the ability to work effectively in the educational community, and sound knowledge of the capabilities and techniques of the medium. If a good balance is not struck between these, the system will be used ineffectively and the goal of improved instruction cannot be met fully.

Consider the man with good educational qualifications but a poor background in television capabilities and techniques. He may get along well with his colleagues, and others may consider that he is doing his job effectively. But everybody operates within his own frame of reference, and his television productions will often look like unrelated pieces of classroom teaching. The capabilities of television as a medium different from the medium of the classroom are unlikely to be developed. To call the staff unimaginative is pointless and unfair; the imaginative use of anything—television camera, classroom environment, or budget session—requires knowledge and experience.

Interestingly enough, ineffective use of the medium may also result from the employment of a person who is skilled in television production but lost in the field of education. True, the bad productions may look a little fancier, but they will be bad nevertheless. The reason is that either of two things is likely to happen.

First, the television man, recognizing his instructional inadequacies, leans heavily on the teacher or curriculum developer. Unfamiliar with instruction principles and reinforced only by recollections of his own school days, he can do little more than assemble on tape the ideas given him by "those educators." Since they are oriented to the classroom and not to television, the programs once more come out looking like facsimiles of classrooms.

Second, the television man often does not recognize his instructional inadequacies and attempts to re-make the "old-fashioned" educational system. The results of this approach are too painful to elaborate further.

ITV is still so new that few of its leaders set out with instructional television as a career goal. Rather, they began as classroom-oriented teachers or administrators, or as television practitioners, and found that they could broaden their professional skills into new areas.

Some television practitioners have become excellent in curriculum development, and some classroom teachers have become fine television producers. Here the key word is **become.**

In summary: In staffing your ITV facility, the man you are looking for is not likely to be on your present staff, and he is probably not a commercial television practitioner who comes equipped only with the required techniques. More and more professionals are qualifying themselves specifically for educational communications. If you can locate one, hire him at once. If you cannot, insist on further training for the man you choose. Your ITV system is too expensive and its potential too great to whittle away its chances through the wrong staff assignments.

STUDENT PRODUCTION HELP vs. PROFESSIONAL CREWS

Consider the Saturday football game or the evening newscast on the home television set. The pictures are in focus. They change as the program progresses so that you see what's important at any given moment. The screen is neither darkly muddy nor overly bright. In other words, you can concentrate on what the program is about, not on how it is done.

Clean, unobtrusive production is accomplished by people who are skilled and practiced at their jobs, whether they are directors, cameramen, lighting technicians, or control equipment operators. This technical smoothness is needed not merely so the program will sound and look "professional," but so that the program will do what it is supposed to do.

Technically awkward production interferes with communication. The viewer is asked to dig out the intended ideas even though he cannot hear well, or the crucial picture is out of focus, or he is being told about one thing but shown another. Any number of elements can interfere.

And that is the essential argument for using professional production crews rather than students in the production of instructional television materials.

Students, however, are commonly used in ITV production, whether the installation is in an elementary school or in a university. The reasons for using them are usually that they are available, cost little or nothing, and the television experience is good for them.

They are undeniably available; the price is right, and they usually enjoy the job. Whether the experience is good for them probably depends upon the individual. If the production is a laboratory session tied to a college broadcasting course, the experience is at least logical. If the production is conducted by sixth-grade boys, the value to them is less clear.

But if the ITV production process is intended simultaneously to be a learning experience for the crew, serious questions of means and ends arise. For example, if you are teaching sixth-grade social studies, you may give Johnny Smith an **A** for his paper on Honduras, but if you are also writing a sixth-grade social studies textbook, Johnny's paper will not likely be incorporated in it. Excellent performance in one context does not constitute excellent performance in another. As for Johnny's performance as a cameraman, you must decide whether you are teaching him a skill or producing an instructional program for other students.

In ITV production, one should avoid anything that cuts the chances of realizing the program's instructional objectives. If the program benefits the production crew, that is all to the good as long as the quality of the program is not impaired.

That principle need not rule out the use of student crews, but it implies certain guidelines, described briefly as follows.

1. Students should have acquired technical skills before they are assigned to ITV crews. Actual production can be good experience for students, but it is no place to build basic skills.

2. Within ITV crews, students should be assigned so that their skills are used to support the production, and not so that the production will help overcome their weaknesses.

3. As Aristotle said, the audience (and not crew training) is the end and aim of the production.

Some additional factors should be considered when students are used in production crews.

1. When students are used in production, the job generally takes longer than when done by professional crews. Even the best students are relatively slow to pick up instructions, they need more detailed direction than professional crew members, and they are more likely to make mistakes.

2. This longer production process may well affect the performance of the TV teacher. When the process drags, some of the intuitive sparkle and spontaneity are likely to sag.

3. The presence of students may affect the relationship between the TV teacher and the director.

4. Students' class schedules are a continuing complication in crew scheduling.

The above notwithstanding, many successful ITV programs have been produced with student crews, and many productions would not have been done were it not for the availability of student crews. Nevertheless, it is well to consider all sides of the problem before assigning to students tasks that ordinarily require professional attention. If you have been told that there is not really that much difference between student and professional performance, call your commercial TV station manager and ask him what he pays his production crews and how difficult it is to recruit good ones.

Chapter X

PLANNING THE ITV SYSTEM

HOW DO YOU PLAN an ITV system? There is, of course, no single way. The kinds of systems are many and diverse. There are, however, a few basic decision points and a few principles which, while they may seem obvious, also appear to be workable. This chapter discusses some planning principles, the roles of those involved in planning, and comments on quality and cost.

PATTERNS FOR PLANNING

Here is a basic planning pattern—

1. Take a long and careful look at your entire instructional and administrative communication requirement.

2. With good professional help, relate the potentials of television to your tasks. While reserving the final decisions for yourself, take the professional counsel seriously unless you are already expert in television.

3. You may then decide that television is not the answer, that the potentials of television in fact do not match your requirements.

4. If you decide in favor of television, now is the time to make policy as specific as possible. In detail, and with the advice of those who know the medium thoroughly, set forth your objectives which should include the following broad categories:

   - Students and professional groups to be served
   - Nature of material to be transmitted
   - Amount and kind of production to be undertaken, if any
   - Nature of related systems, such as feedback systems to computer centers and dial-access components

5. Engage the best telecommunications design engineer that you can afford.

6. Making full use of consultant help, design the technical system, determine the staffing requirements, and plan specific administrative arrangements.

7. Budget for operations and capital outlay.

8. Build in budget factors for future development.

9. Decide whether you can afford the package developed thus far. (Although you have money invested in planning, you have not yet bought any hardware.)

10. If you cannot afford it, congratulate yourself on having found out before it was too late. Then decide on alternative courses: modify plans, phase the development, or forget the whole thing.

11. If you opt for modification, play the game fairly and go back to step 4, the determination of objectives. If at this point you can reduce the size of the project and yet retain the same objectives, somebody has been cheating.

12. Having decided that there is conformity between objectives and plans, proceed with construction. Ideally, your principal staff person should now be brought into the picture so that he can supervise construction and add his personal touches while the installation is still taking shape.

66

KEY ROLES IN PLANNING

Having established these guidelines, what are specific roles to be undertaken by key people?

Educational Administrator

The administrator's traditional functions are to set policy, allocate resources, and supervise operations. And so it is in planning an instructional television system. The administrator's basic tasks are to—

- Decide whether to use television.
- Set the objectives of the system.
- Allocate funds.
- Set the ways in which the system will fit into the overall structure of the educational enterprise.
- Supervise staffing in accordance with the previous decisions.
- Determine whether the ITV project meets the stated objectives. If it does not, establish corrective measures.

This bare statement, however, sets forth critical tasks without touching on some of the most important problems likely to be faced by the administrator.

Modern communication does not merely permit one to do more conveniently the same things he always did. It has been pointed out that the elevator did not merely make it unnecessary to climb stairs; it made possible the development of the skyscraper. Similarly, modern communication technology allows one to reexamine the structure of instruction and administration. Television is pervasive. It tends to be felt throughout the system. Many people are touched by it, and some are likely to feel threatened or bypassed. As in so many areas of successful innovation, the name of the game is **Involvement.** And this, you would probably agree, requires the most crucial and ingenious forms of leadership.

During many of these steps, the administrator should have appropriate consultant help. The decision to use television should come only after a study of alternatives. The allocation of funds can be made most judiciously in steps, beginning with feasibility studies, so that the financial commitment at any stage is no greater than necessary. The objectives of the system, and the way the system can fit into the overall educational structure, can be moulded and sharpened by a person skilled in system development and implementation.

Classroom Teacher

For the classroom teacher, television tends not to be "just another classroom resource," but a day-in, day-out part of the curriculum. When properly used, it greatly enhances the teacher's creative role and helps make possible a more individualized relationship to the student. Teachers, therefore, should be involved in the planning process. Their likely roles would be to—

- Participate in advance studies on the use of educational technology in your situation.
- Learn about the uses of television in instruction and the techniques of classroom utilization.
- Help determine the objectives of the television system, and set priorities among possible uses of the medium.
- Participate in curriculum committees to determine the objectives and content of specific series.
- When the system is operational, provide feedback on the usefulness of materials, ideas for improvements of further development, and recommendations for relating television to other instructional methods.

Most teachers have long since dismissed the shibboleth that television will somehow replace them. People working day by day in instructional television almost invariably find that good classroom teachers are their best friends, providing extremely valuable advice and strong moral support.

Television Administrator

The instructional TV administrator—the person who runs the ITV system—should be a generalist who knows instruction, understands the capabilities of his medium, and can apply these capabilities in specific situations. In addition to the three basic qualifications needed by the ITV administrator, mentioned in the previous chapter, he must also be able to—

1. Supervise the construction of the system and its subsequent maintenance.
2. Set the working goals of the system within the established policy objectives.
3. See that the system is operated in accordance with these goals and objectives.

4. Recommend changes in objectives, budgets, procedures, personnel, or equipment according to what he considers to be the continuous improvement of the system.

5. Maintain close liaison with the other aspects of the curriculum effort.

6. Maintain sound working relationships (concentrating on open communication lines) with teachers and other instructional TV personnel.

7. Select and supervise personnel.

8. Maintain careful cost records and work toward cost efficiency improvements.

9. Regularly evaluate the performance of the system in the light of stated objectives.

10. Recommend or execute necessary changes.

Consulting Engineer

The following are some of the questions that administrators should ask themselves concerning consulting engineering services, some-rule-of-thumb costs, and how to establish a sound working relationship between administrator and engineer.[1]

Do you really need a consulting engineer?

The answer to this hinges largely on at least two important factors: the size and scope of the project contemplated, and the qualifications and experience of the existing technical staff. Two extreme cases will illustrate the point. It would be absurd for a large television station, manned by a competent staff, to retain outside professional counsel when purchasing a relatively minor item of equipment. It would be equally absurd for an institution plunging into an ambitious television development to commit large amounts of money without the advice of an experienced consulting engineer.

The reputable consulting engineer is independent, has no allegiances except to his clients. He has no ties with any equipment manufacturer or supplier, and he starts with your objectives, and not with somebody's line of hardware.

Should you retain a consulting engineer? While the answer is not always obvious, the question is always worth asking. If there is some doubt, the chances are that you should retain one. You will probably find yourself ahead both in terms of finance and the effectiveness of your system.

How do you go about selecting a consulting engineer?

A good engineer's main stock in trade is his reputation, which is based on successful and satisfactory service over a long period to a large number of clients. At least one good approach is to conduct an inquiry of established institutions who have retained consulting engineers. Ask them for their recommendations.

Virtually all States have engineering registration boards or engineering societies which publish a directory of registered professional firms. These directories may be helpful in locating a consulting engineer. Some of these societies may also publish guides to assist in the selection and compensation of consulting engineers. Much of the information in this section is taken from such a directory.

What can you expect from the engineer or firm?

The first and foremost answer to this question is the obvious one: honest and objective engineering advice based on long experience and training. This is further explained in outline form below[2] showing that one can expect the consulting engineer to—

> Inform himself fully in regard to the scope and services required for each project and to have the experience and ability to qualify him for the services to be provided.
>
> Provide the staff and facilities necessary to furnish the complete service through all phases of preliminary planning, design, and construction.
>
> Retain and confer with specialists on unusual matters outside the scope of his regular services.
>
> Have the experience and ability to analyze and design the most economical improve-

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[1] Some of the material in this and the following sections is taken from the **Directory and Guide for Selecting and Compensating Consulting Engineers,** published by the Consulting Engineers of Florida, Florida Engineering Society, 1966-67. Orlando, Fla.: The Society. The Florida Engineering Society is affiliated with the National Society of Professional Engineers.

[2] Ibid., p. 5.

ment consistent with budgetary limitations, expected life of improvement, and latest technical advancements.

Perform the services in an expeditious manner.

Furnish experienced construction observers who will keep the client advised on engineering matters pertaining to the construction project, and who will work toward the goal of obtaining the results prescribed by the plans and specifications.

Possess the ethics and qualities of a professional man and to represent the client in accordance with the highest standard of professional conduct.

What services should a consulting engineer provide?[3]

Preliminary report services, which broadly include feasibility studies and preliminary engineering studies that indicate the problems involved and the alternate solutions available, financial investigations, preliminary layouts and sketches, analyses for future development, general cost estimates, and the consulting engineer's recommendations.

Design services, which are ordinarily divided into a preliminary design phase and a final design. Design services usually include preparation of detailed drawings and specifications, assistance in the preparation of documents such as the engineering sections of FCC applications, final cost estimates, and assistance in working with bidders and contractors.

Professional services during construction, which normally include periodic site visits, interpretations of contractors' drawings and documents, and a final inspection to determine that the specifications were met and the system operates as designed.

Additional services, such as resident project services, accommodation of changes in the project, furnishing additional copies of reports, assistance in staffing the completed installation, and serving as expert witness in proceedings related to the project.

What kind of information or guidelines should be provided to the engineer?

To crystallize his own requirements and provide a base for a contractual arrangement with the engineer, the client should write a complete description of the proposed project. Such a description should begin by stating the educational goals of the project clearly and completely. The remainder of the description should include budgetary limitations, the anticipated starting and completion dates for the project, and all other factors that may affect the agreement for proposed engineering services. If a formal contract is drawn up, it should explicitly include such matters as the kind of raw information the client will provide, the engineer's proposed schedule, compensation arrangements, and such detail as the cost of additional copies of the project report, and so forth.

How much should such services cost? Can you really afford the services of a consulting engineer?[4]

A good consulting engineer, retained early in the planning stage of the project, is likely to save more than he costs. Furthermore, the system he designs has a high probability of success, both for cost effectiveness and educational goals.

A major university recently completed a new building which theoretically included full provision for instructional television. A consulting engineer was then called upon to work out the system. After a careful study he was forced to report that the university had two alternatives—

- Make expensive and time-consuming changes in the brand-new building, abandoning the carefully installed conduit system without ever using it, or
- Change the educational objectives of the building, the cost of which was $2 million.

An early investment in consulting engineer services clearly would have been a wise move.

The engineering profession points out certain financial pitfalls, as described below.

COMPETITIVE BIDDING.—Minimum overall costs of the completed project, including construction, operation, maintenance, engineering, legal and financing, should be the goal. As engineering judgment and analysis affect all costs, the best qualified engineers will produce the most economical project. The profession is united in the belief that competitive bidding for professional engineering services is in the interest neither of the client nor the engineer and is considered unethical.

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[3] Ibid., pp. 6-8.

[4] Ibid., pp. 10-11.

SO-CALLED "FREE-ENGINEERING."–One should be alert for an arrangement whereby the engineering is "free." Adequate engineering is never free. In such an arrangement the charges for engineering services can only be hidden, and the total cost will most likely be greater than if the charges are clearly identified. Packaged arrangements combining both engineering services and construction invariably involve a conflict of interests detrimental to the client and the public.

CONTINGENT CHARGES FOR PROFESSIONAL SERVICES.—To retain an engineer on the contingency that the engineer is compensated only if a project proves feasible or that construction work will be performed in the future is neither in the best interest of the client nor the profession.

A consulting engineer may be compensated for his services in various ways, and different bases may be used for compensating the professional engineer in private practice, depending upon preference or circumstances.

The following methods for compensating the engineer or the engineering firm are recommended:

LUMP SUM.—When it is possible to define clearly the scope of the project and the engineering services to be performed, the lump sum charge may be agreed upon for total compensation. The scope of services should be described completely in the agreement to avoid possible misunderstandings. Any contract of this type should provide for payment for additional services on an agreed basis.

PAYROLL COSTS TIMES A MULTIPLIER.—When the scope of work and professional services cannot be clearly defined, the charge may be based on payroll costs including salary plus all benefits such as vacations, sick leaves, insurance, record costs, and other fringe benefits, times a multiplier which usually ranges from 2.00 upward. In addition to compensation as computed by this method, reimbursement should be made for travel, subsistence, telephone, telegraph, cables, prints and printing costs, and general out-of-pocket expenses required specifically for the project.

TOTAL COST PLUS A FIXED CHARGE.—This method of payment is a variation of the payroll costs times a multiplier method and applies under similar conditions. The engineer should charge all costs (payroll, overhead, travel, telephone, subsistence, and similar out-of-pocket expenses) plus a fixed dollar amount for profit.

PERCENTAGE OF CONSTRUCTION COSTS.—Percentage of construction costs is a method which has been used extensively in the past for establishing compensation for professional services. While there has been a definite trend away from this as a basic method in projects for which the scope can be established, it has been used for many years and may be desired by clients who have traditionally relied upon it.

The cost curve is a guide which sets forth a range of charges for design services and professional services. (See figure 19.) For the purposes of establishing charges for the separate phases, the following allocation of the charge as computed from the cost curve is suggested:

A. DESIGN SERVICES

Preliminary design phase—up to 40 percent of the charge computed from the curve.

Final design phase—up to 80 percent of the charge computed from the curve.

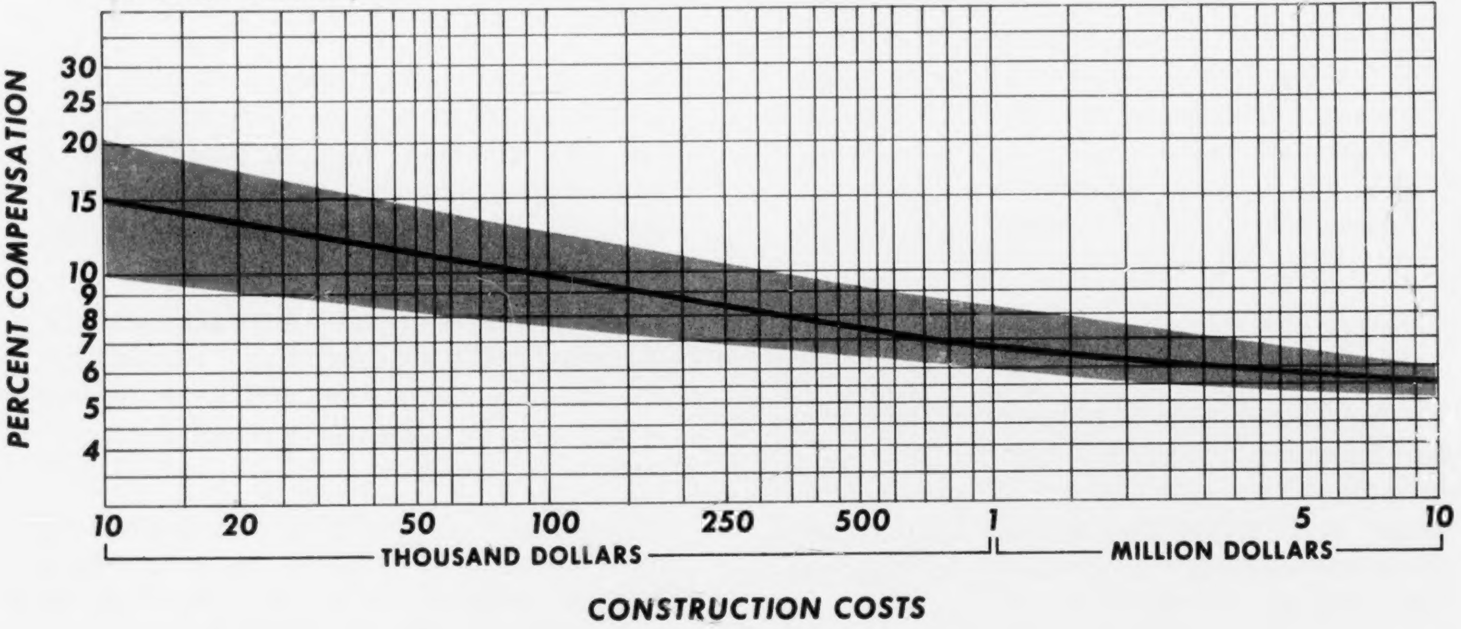
B. PROFESSIONAL SERVICES DURING CONSTRUCTION

Up to 40 percent of the charge computed from the curve.

The cost of preliminary report services and additional services are in addition to the cost reflected by the curve.

Fig. 19. Range of compensation for professional engineering services.

The costs reflected by the solid line represent projects of average difficulty. Projects of less difficulty shade downward and projects of more than average difficulty shade upward. In all cases the curve reflects cost of new work only.



The percentage charge from the cost curve is applicable to each construction contract for which separate designs and contract documents are to be prepared.

The costs reflected by the solid line represent projects of average difficulty. Projects of less difficulty shade downward, and projects of more than average difficulty shade upward. In all cases the curve reflects cost of new work only.

Alterations, renovations, and additions fall above the cost reflected by the curve. Compensation for these services is not covered by the curve and compensation should be by one of the other methods.

PER DIEM RATES PLUS EXPENSES.—Per diem rates for personnel plus out-of-pocket expenses required for the project normally are used for short-time engagements, especially for personal services involving advice, reports, investigations, and similar types of activities for which little or no design, detailed drafting, or other services are required.

The per diem rate for principals of firms usually ranges upward from $150 per day plus out-of-pocket expenses for all time spent on the work in any 24-hour period. A lesser charge is made for engineering personnel other than principals. In this case the charge method should be payroll costs times a multiplier.

Time should be measured portal-to-portal and charged from the office or base involved. A minimum of one-half day should be charged on irregular work required out of the office or base, with telephone office consultations on an hourly basis.

Rates for consultation in connection with litigation and appearance before commissions and courts usually range upwards from $150 per day plus out-of-pocket expenses. However, if appearances in court require more than 2 days per week, the per diem rate should range upward from $175 per day.

RETAINER.—The employment of professional engineers on a retainer basis is a common practice which assures the client of always having available the services of a professional engineer. The amount of the retainer varies with the character and value of the professional engineer's service to the client. The terms of agreements for services on a retainer basis vary widely. Compensation may be based on a fixed sum paid monthly or some other mutually agreed basis.

COMBINATION OF METHODS.—Various combinations of methods for determining total compensation for professional engineering services may be desirable for some projects. Some projects may require rather extensive investigations and analyses before the scope of the project and services are known. For example, this situation may be covered by payroll cost times a multiplier plus out-of-pocket expenses until the scope is developed, then by lump sum for the remainder of the service.

Educational Telecommunications Consultants

When the consulting engineer designs a system, he needs the most precise information about its intended use, likely growth, future implementation, and similar information. As the educational administrator contemplates his future system, he needs to know as much as possible about the instructional potential of various technical approaches, the administrative pitfalls encountered by others, some tested means of introducing the system and encouraging its use, and the budgetary realities likely to be encountered later.

The healthy project accounts for such variables as the impact of internal organization, the possibilities of cooperation and program exchange with neighbor systems, national trends in the use of educational technology, and the "blue-sky thinking" that may turn out to be tomorrow's commonplace.

The man who is called upon to assist both the administrator and the engineer in weighing these factors and shaping the final project is the educational telecommunications consultant. Generally speaking, his functions may be to:

1. Assist the educational administrator in determining which of his educational objectives may be furthered through the use of communications technology, and how.

2. Help sharpen the educational objectives of the future system, probably working with local committees as well as with administrators in the process.

3. As the project begins to take shape, work with the consulting engineer in examining the alternative technological solutions to the problems posed and recommending courses of action.

4. Develop budgets for operations and administration of the system as the engineer develops technical budgets.

5. Work with administrators as requested in staffing the system.

6. As an impartial outsider, work with local groups in introducing the system, acquainting staff members with its potential, and helping them learn to use the system in a way that is helpful to them and furthers the educational objectives of the project.

7. Assist in evaluating the system and its use. Work with the educational administrator, consulting engineer, and local system staff in making adjustments or corrections if necessary.

A consultant in educational telecommunications is going to be different things to different people. In relatively small projects that have comparatively obvious educational objectives, an outside consultant may not be a worthwhile investment. If a substantial amount of money is to be spent, and if the system will have a significant impact on the work of the educational enterprise, it is probably useful to involve a professional who has unusual knowledge of the technological alternatives as they bear on instructional problems—one who can work with local people but who has no local axes to grind.

Probably the most reliable source for information about educational communications consultants is through the major professional associations, such as the National Education Association, the National Assocation of Educational Broadcasters, and the Joint Council on Educational Telecommuncations. These and other sources are discussed in the following chapter.

Architect

The architect's role may or may not be particularly important to this discussion, depending on the size and nature of the project. In general, the role of the architect is familiar enough that there is little point in reciting it again, but some specific ideas may be of use.

Like the consulting engineer, the architect needs information. Before he can do a sensible job, he needs to know in detail the requirements of the structure—not clients' renditions of floor plans, which are probably the bane of his life, but the results of a commonsense, thorough study of the total project and of each individual function.

If the project is relatively conventional, the architect most often goes to work seriously **after** the consulting engineer has completed his basic study and the hardware portion of the planning is well advanced. The engineer's work provides input for the architect. This is not to say that the architect comes in after the engineer has gone home. Their work overlaps.

In a major development or if unusual approaches are being attempted, the architect and the engineer should join forces on the project as early as possible. Given an opportunity to interact **early,** the two can avoid waste motion in planning and wasted money in construction.

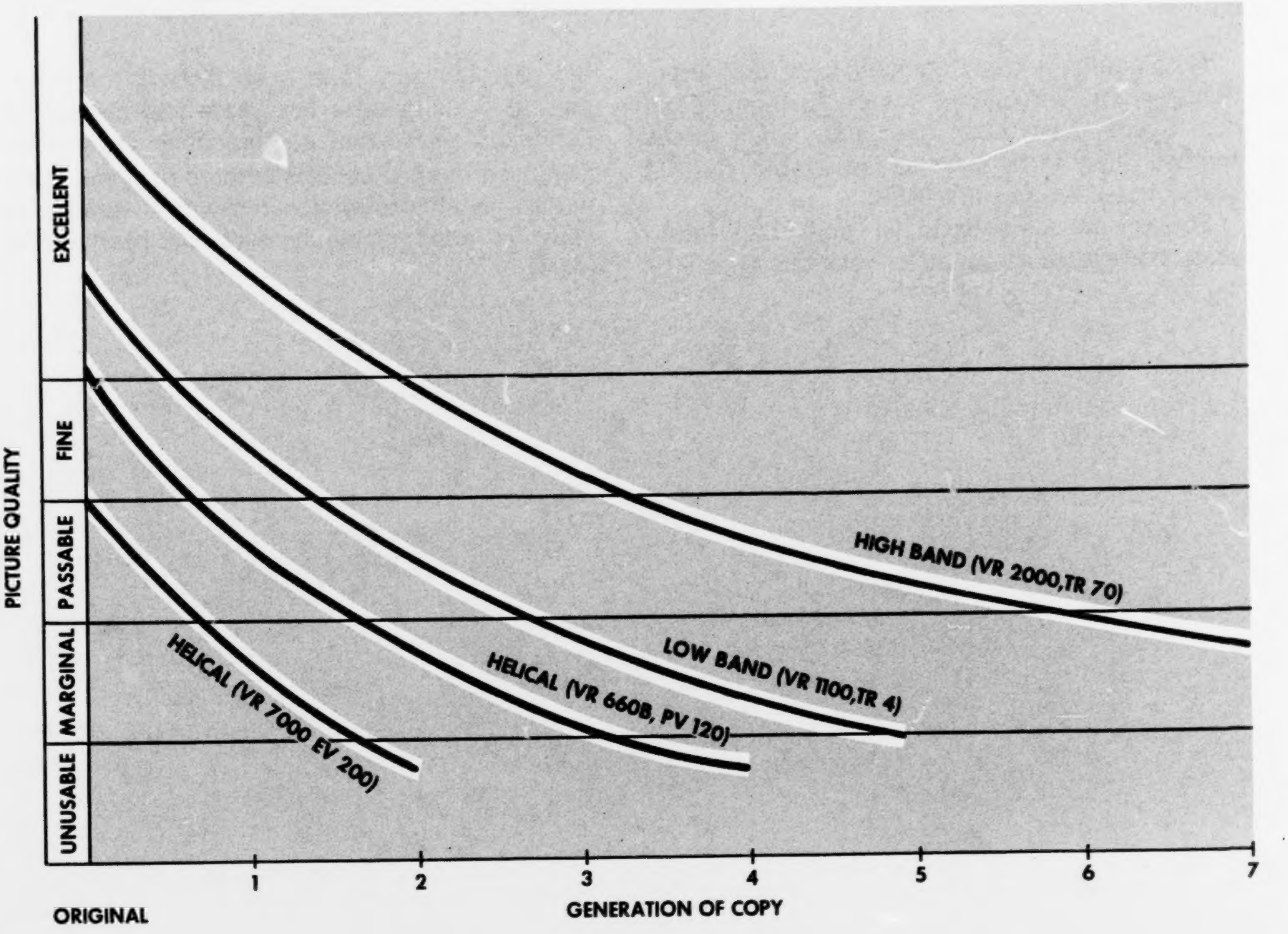
By the nature of his job, the architect is an experienced middleman. He is accustomed to sitting in a conference and winnowing out ideas to be related and put to work. This capability should not be overlooked as planning progresses.

THE QUALITY SLOPE

In planning for equipment, from time to time one hears something like this: "Why buy the expensive camera? The classroom receiver cannot reproduce that good a picture."

This idea has a certain surface logic, but it is based on a misconception. The picture signal that arrives at the receiver is never as good as the signal that left the camera. Minor impairments and degradation take their toll. They can be minimized, but they exist. If you begin with a picture that is only as good as the receiver will display, the picture as finally displayed will be terrible.

Fig. 20. Quality slope showing progressive impairments introduced by parts of the television system.



This problem can be demonstrated by the simple graph in figure 20. A study of the graph will also make the remedies obvious. The graph shows that the initial quality of the studio scene is extremely good. As it is converted into electrical signals and passed through the production hardware, however, small impairments creep in. Each flaw may be so tiny as to be imperceptible, but the cumulative effect is already at work.

Quality takes a sharp drop in the process of recording and playing back the program. Still other small degradations are introduced by the transmission machinery and the process of broadcasting or cable transmission. Antennas and distribution systems add their small errors. Videotape recording at the reception point may cause another sharp drop.

Finally, degradation introduced by receivers may be enough to drive the final picture—the only one that matters—into the "unusable" category.

Given the simple fact that a quality slope of some magnitude will exist, how can one assure that the classroom picture is good enough? A look at the diagram will point the way.

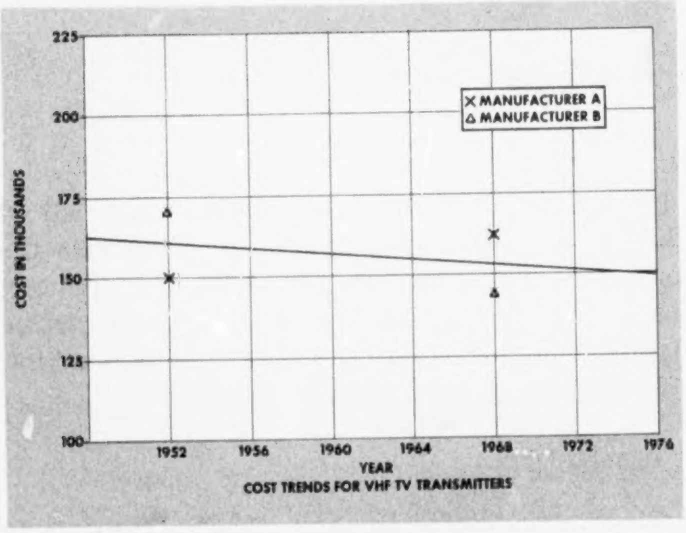
1. Start higher on the quality scale; the same slope angle could then bring receivers into the useful range.
2. Reduce the sharp vertical drops caused by recording by investing in better recorders or perhaps by eliminating one of them.
3. Raise the quality of production, transmission, and distribution systems to flatten out of the angle of the quality slope.
4. Raise the quality of the classroom receivers, which cause a sharp drop in final quality.
5. Devise some combination of the above four possibilities.

COST TRENDS

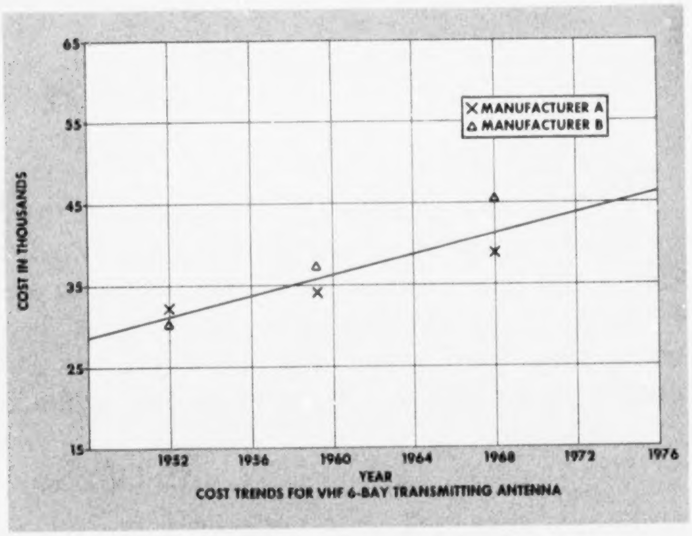
No planning is complete without careful attention to costs. Throughout this publication, actual cost figures have been used only when prices seemed likely to be more or less stable. Current costs quoted are for mid-1968.

To provide some basis for projecting future costs, however, cost trends for selected items over the past 15 years have been plotted, the resulting curve extended a few years into the future. Figure 21 shows that equipment in general has advanced in price about 3 percent per year. Some items—notably television receivers—have come down in price markedly over the past several years.

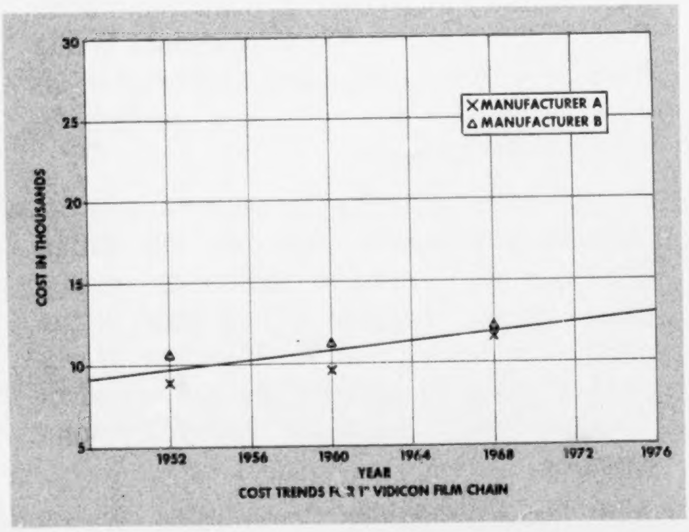
Fig. 21. Cost trends for selected television equipment items, 1952-68, with some projections to 1976.



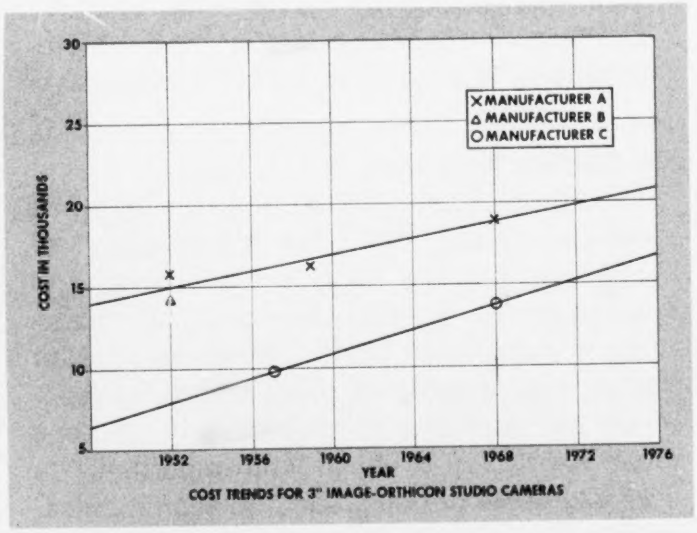
COST TRENDS FOR VHF TV TRANSMITTERS



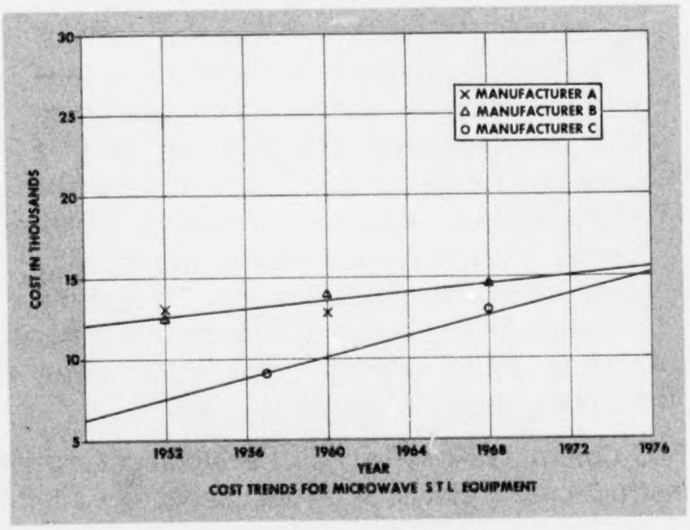
COST TRENDS FOR VHF 6-BAY TRANSMITTING ANTENNA



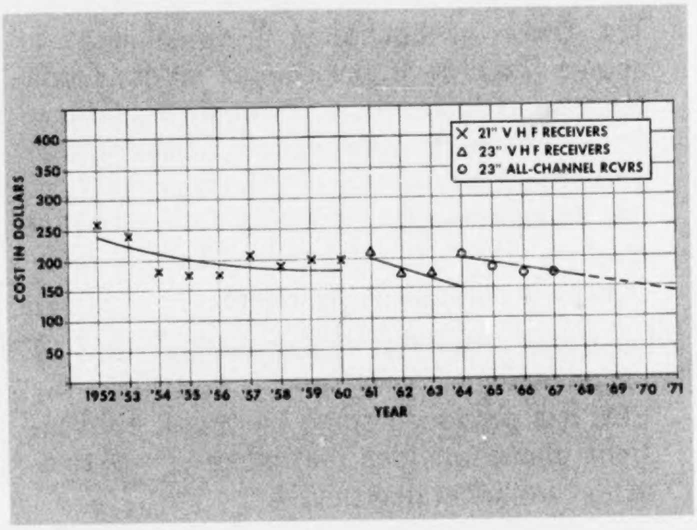
COST TRENDS FOR 1" VIDICON FILM CHAIN



COST TRENDS FOR 3" IMAGE-ORTHICON STUDIO CAMERAS



COST TRENDS FOR MICROWAVE S T L EQUIPMENT



Chapter XI

WHERE TO GET HELP

THERE ARE COMPETENT advisers on many university faculties, and there are valuable lessons to be learned from many fine operating systems. As plans are developed, you may wish to consult the latest specialized publications or visit people responsible for comparable projects. There is no such thing as an up-to-date list of "latest and best" publications and projects because the situation changes daily. But the professionals in the following organizations can be helpful in steering you to the right consultant, the latest book, or model installations.

PROFESSIONAL SOURCES

American Association of University Professors, 1785 Massachusetts Avenue, NW., Washington, D. C. 20036

This organization has done some effective groundwork regarding the relation of professors to television and other new media.

Corporation for Public Broadcasting, 555 Madison Avenue, New York, N.Y., 10022

The Corporation for Public Broadcasting was created by the Public Broadcasting Act of 1967, as a major force in the support and development of noncommercial broadcasting in the United States. While its mission does not emphasize instruction, its support of educational broadcasting stations can hardly fail to be of vital importance to all segments of educational telecommunications.

Department of Health, Education, and Welfare, Office of Education, Washington, D.C. 20202

The Office of Education is valuable as a source not only of grant and contract funds but also of information. Through the Educational Resources Information Center (ERIC) and other components of the Office, such as the Educational Broadcasting Facilities Program, a wealth of educational and TV technological material is available.

Educational Facilities Laboratories, Inc., 477 Madison Avenue, New York, N.Y. 10022

EFL has produced some landmark publications about facilities that make use of television and other new media.

Educational Media Council, 1346 Connecticut Avenue, NW., Washington, D.C. 20036

EMC is a meeting ground for education and the industries involved in educational media. Its magnum opus is the **Educational Media Index.** EMC is a continuing source of information both as an entity and through its varied constituency.

EDUCOM, Interuniversity Communications Council, 9650 Rockville Pike, Bethesda, Md. 20014

EDUCOM is a relative latecomer among these groups. It began with a base in the medical sciences, but its interests broadened at once to include the full range of communication problems faced by universities.

Federal Communications Commission, Washington, D.C. 20554

The FCC has a responsibility for instructional communications in that it regulates educational television and radio stations, ITFS systems, common carriers such as telephone companies, and, to an increasing extent, cable systems. The FCC has taken a generally sympathetic attitude toward the requirements of education, reserving broadcasting channels and creating the Instructional Television Fixed Service. Through its Educational Broadcasting Branch, the Commission offers valuable information about the many fields within its purview.

FCC Committee for the Full Development of the Instructional Television Fixed Service, Federal

Communications Commission, Washington, D.C. 20055

This committee and its various regional groups act as a valuable coordinating agency as ITFS develops throughout the country. In addition, the Committee has provided much information about this extremely useful television service.

Ford Foundation, 320 East 43d Street, New York, N.Y. 10017

The Ford Foundation has supported an impressive amount of research and thoughtful writing about education and the applications of technology.

Joint Council on Educational Telecommunications, 1126 Sixteenth Street, NW., Washington, D.C. 20036

This is a council of associations formed to assist the educational community in developing technology for education. Originally formed as the Joint Committee on Educational Television, its mission was to secure reserved channels for ETV in the FCC deliberations of 1950–52. Including such groups as the American Council on Education, the Council of Chief State School Officers, the National Education Association, National Association of Educational Broadcasters, and half a dozen others, JCET has evolved into an organization that essentially establishes an education perspective on developments in the entire field of telecommunications, from telephones to satellites and beyond.

National Association of Educational Broadcasters, 1346 Connecticut Avenue, NW., Washington, D.C. 20036

The NAEB is the professional association of educational broadcasting. Through its Educational Television Stations and National Educational Radio Divisions, NAEB represents most of the educational broadcasting station operators in the country. This organization established and supervised the landmark instructional television project in American Samoa, undertook the Educational Communications System study on telecommunications networks, conducted the important National Project for the Improvement of Televised Instruction, and has participated in the design of many ITV systems around the world. Through its Instructional and Professional Services Division, NAEB serves the interests of those who use television and radio for instructional and administrative purposes.

National Education Association, 1201 Sixteenth Street, NW., Washington, D.C. 20036

The NEA and its various departments have conducted studies and produced publications on subjects ranging from the rights and responsibilities of teachers to cable television systems, the Instructional Television Fixed Service, and the problems and opportunities of planning educational facilities using new media. The Department of Audiovisual Instruction (DAVI) has done much work with ITV and its relationship to other media as well as the total instructional problem. NEA has also figured prominently in the long evolution of a new copyright law and in the development of ITFS.

National Society of Professional Engineers, 2029 K Street, NW., Washington, D.C. 20006

This Society is concerned about standards of engineering practice, and has published standards, operating guidelines, and related helpful information.

PROGRAM SOURCES

The following agencies are sources of programs. Their personnel can tell you what is available, for how much money, and when. Although National Educational Television is not centrally involved in instruction, it is included because of its importance to educational television nationally and because certain of its products have much more importance to education.

Great Plains National Instructional Television Library, University of Nebraska, Lincoln, Nebr. 68508

Midwest Program on Airborne Television Instruction, Memorial Center, Purdue University, Lafayette, Ind. 47907

National Instructional Television Center, Box A, Bloomington, Ind. 47401

National Educational Television, 10 Columbus Circle, New York, N.Y. 10019

Chapter XII

CONCLUSION

IT IS ALL TOO EASY to take an advocate's view of instructional television. Television and related technology are potentially so much more than "just another classroom tool." Through their use, the dream of equal educational opportunity is brought closer to reality; truly individualized instruction is no longer a vague piety.

Given this potential on the one hand, and on the other the familiar traditions and the established patterns, it is small wonder that instructional television is perplexing as well as challenging. Ideally, instructional television should be designed into a system of education when the system itself is created, and it should be used by teachers and administrators who are as proficient and comfortable with television as with books or telephones or electric lights. Since that will probably not be possible for a couple of decades, one must plan all the more carefully.

Planning television systems is fraught with certain common pitfalls. Fortunately, enough other institutions have already spent sufficient resources on these pitfalls—in terms of time, money, and effort—to gain the experience that may help you avoid them. This book has tried to point out the traps and suggest ways to chart a safer course to more effective instruction with the aid of television devices and systems.

The major points stressed are summarized below:

Get help

Seek competent professional consultant advice at the earliest point possible in your planning. Such help is available, and it can save you in the long run.

If you start small, don't think your project won't grow

Don't make the mistake of buying equipment only for today's project—no matter how cheap or flexible or versatile or self-contained or easy-to-operate or needs-no-maintenance. The constantly recurring experience has been that inevitably, and often immediately, more is wanted of the equipment than was originally intended. Evolving possibilities and needs for use of instructional television systems become increasingly apparent as the systems are used. Serious thought, therefore, should be given to future growth, convertability, compatibility, quality levels, and other requirements.

If it has been done before, don't waste time and resources proving it all over again

Do not waste time and resources trying to prove all over again what has already been established—that properly planned and adequately maintained instructional television equipment and systems have been found to be essential and invaluable in improving the educational systems throughout the world.

If you plan only to televise current classroom performances, you will fail to make full use of television's potential

Any television equipment or system intended to contribute to the improvement of instruction but the use of which is limited to televising a teacher's usual classroom performance can represent an appalling waste of potential. Therefore, don't commit funds for the purchase and operation of television equipment or systems until you are also prepared to commit sufficient financial and human resources for the optimum potential of television.

In conclusion, the two cardinal principles presented earlier merit repeating:

1. Think first about educational objectives and second about technology.

2. Get expert advice before the planning process is far advanced.

As we began our first page with a thought from a wise man, we conclude our last with a quotation from another. In his **Journal** of April 10, 1854, Henry David Thoreau wrote:

> I bought me a spy-glass some weeks since. I buy but few things, and those not till long after I began to want them, so that when I do get them I am prepared to make a perfect use of them and extract their whole sweet.

☆U.S. Government Printing Office: 1969 O—353-053